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 رقم المشروع PROJECT NO 30403		المملكة العربية السعودية KINGDOM OF SAUDI ARABIA المؤسسة العامة لتحلية المياه المالحة SALINE WATER CONVERSION CORPORATION (SWCC)												
		نظام نقل مياه الجبيل – الرياض Jubail-Riyadh Water Transmission System												
JACOBS ZATE المهندس ENGINEER		Jacobs, Zamel & Turbag Consulting Engineers												
 شركة الراشد للتجارة والمقاولات AL-RASHID TRADING & CONTRACTING CO. المقاول CONTRACTOR		Al-Rashid Trading & Contracting Co.												
		Permanent Cathodic Protection System Design For B1 & B2 Packages Pipelines												
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<div>1.1GENERAL<div>Specialized Oil & Gas Engineering Co. Ltd. (SOGEC), a Cathodic Protection specialist company, has been awarded a subcontract by Al-Rashid Trading & Contracting Co. to provide Cathodic Protection System services for pipelines under Jubail-Riyadh Water Transmission System project for SWCC, Saudi Arabia.<div>CP vendor scope of work includes, CP system detailed engineering, material supply, Supervision of installation, testing and commissioning.</div></div></div> <div>1.2SCOPE OF DOCUMENT<div>This document outlines the permanent impressed current cathodic protection system(PCP) detailed design package for the 88" water transmission twin pipelines from PS1 to PS2, PS2 to LV3, LV3 to PS3 & PS3 to HPT and single pipelines 60"&80" from HPT/C to HPT/A+B Structure details are mentioned in table 1.<div>This detailed design package for pipelines includes the following,<div><div>• CP system design basis</div><div>• Design calculations</div><div>• Material Specifications</div><div>• Bill of Materials</div><div>• Installation drawings</div></div></div></div></div> <div>Table 1: Pipeline dimensions<table><tr><th>SNo</th><th>Pipeline</th><th>No. of P/L's</th><th>Length (m)</th><th>Diameter</th><th>External Coating</th></tr><tr><td>1</td><td>PS1 to PS2</td><td>Twin</td><td>169729</td><td>88" (2.235m)</td><td>3 Layer HDPE coating</td></tr><tr><td>2</td><td>PS2 to LV3</td><td>Twin</td><td>45455</td><td>88" (2.235m)</td><td>3 Layer HDPE coating</td></tr><tr><td>3</td><td>LV3 to PS3</td><td>Twin</td><td>80230</td><td>88" (2.235m)</td><td>3 Layer HDPE coating</td></tr><tr><td>4</td><td>PS3 to HPT</td><td>Twin</td><td>111647</td><td>88" (2.235m)</td><td>3 Layer HDPE coating</td></tr><tr><td rowspan="2">5</td><td rowspan="2">HPT/C to HPT/A+B</td><td>Single</td><td>622</td><td>60" (1.524 m)</td><td>3 Layer HDPE coating</td></tr><tr><td>Single</td><td>4363</td><td>80" (2.032 m)</td><td>3 Layer HDPE coating</td></tr></table><div>The temporary SACP system(TCP) designs for above structures were submitted as separate documents (see Doc # 70-YF00-S-301& 70-YF00-S-302).<div>Permanent CP components such as test stations,Bond boxes,Road crossing anodes,etc were included in the temporary CP packages.</div></div></div> <tr><td colspan="2">Final Engineering</td><td colspan="3">Contractor</td><td colspan="3">Subcontractor</td></tr> <tr><td colspan="2">ILF</td><td colspan="3">Al-Rashid Trading & Contracting Co.</td><td colspan="3">SOGEC</td></tr>								SNo	Pipeline	No. of P/L's	Length (m)	Diameter	External Coating	1	PS1 to PS2	Twin	169729	88" (2.235m)	3 Layer HDPE coating	2	PS2 to LV3	Twin	45455	88" (2.235m)	3 Layer HDPE coating	3	LV3 to PS3	Twin	80230	88" (2.235m)	3 Layer HDPE coating	4	PS3 to HPT	Twin	111647	88" (2.235m)	3 Layer HDPE coating	5	HPT/C to HPT/A+B	Single	622	60" (1.524 m)	3 Layer HDPE coating	Single	4363	80" (2.032 m)	3 Layer HDPE coating	Final Engineering		Contractor			Subcontractor			ILF		Al-Rashid Trading & Contracting Co.			SOGEC		
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<p>All components installed along with TCP (such as various types of test stations,Bond boxes,Road crossing anodes,etc) except temporary anodes will be retained and utilized for permanent CP.</p> <p>TCP anodes will be disconnected prior to permanent CP commissioning.</p> <p>NOTES:</p> <ul style="list-style-type: none">• The pipelines shall be electrically isolated from station piping by means of isolation coupling.• If the pipelines are not coated internally with a dielectric material, internal coating shall be provided for 6m on both sides of isolation coupling joint/fitting for each pipeline.• The pipeline shall be electrically isolated from any other buried metallic structure at any location along the pipeline.• Main contractor shall ensure CP vendor supervision & inspection for all CP installation activities.• Grounding connections on the pipelines shall be performed via special DC Decoupling devices to avoid direct DC low-ohmic earthing connections of the pipes.								
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<div>2.1 SWCC Standards, Specifications and Reference Documents</div> <p>The following is the list of documents applicable to this project.</p> <div>QC10-H-096, Rev 8Specification E16, Cathodic Protection</div> <div>QA10-G-1057Jubail-Riyadh Water Transmission System</div> <div>Base offer twin line General Specification G02</div> <div>2.2 Applicable/Reference International Standards</div> <div>2.2.1 Applicable International Standards</div> <p>BS EN 12954: Cathodic protection of buried or immersed metallic structures – General principles and application for pipelines.</p> <p>BS EN 13509: Cathodic protection measurement techniques.</p> <div>2.2.2 Reference International Standards</div> <p>ISO-15589-1 “Petroleum and natural gas industries cathodic protection of pipeline Transportation system.</p> <p>NACE Standard SP-0169 “Control of External Corrosion on Underground or Submerged Metallic Piping System”.</p> <p>NFPA 70, National Electric Code.</p> <div>2.3 Project drawings</div> <table><thead><tr><th>DRAWING NO</th><th>DRAWING TITLE</th></tr></thead><tbody><tr><td>70-YF00-S-322 sht. 01</td><td>ICCP System overall layout for Pipelines</td></tr><tr><td>70-YF00-S-322 sht. 02</td><td>ICCP station 1 Layout- @ KM 00+000 (At PS1)</td></tr><tr><td>70-YF00-S-322 sht. 03</td><td>ICCP station 2 Layout- @ KM 00+000 (At PS2)</td></tr><tr><td>70-YF00-S-322 sht. 04</td><td>ICCP station 3 Layout- @ KM 00+000 (At PS3)</td></tr><tr><td>70-YF00-S-322 sht. 05</td><td>ICCP station 4 Layout- @ KM 116+460 (At HPT)</td></tr><tr><td>70-YF00-S-323 sht.01</td><td>Schematic diagram of ICCP station 1 @ KM 00+000 (At PS1)</td></tr><tr><td>70-YF00-S-323 sht.02</td><td>Schematic diagram of ICCP station 2 @ KM 00+000 (At PS2)</td></tr><tr><td>70-YF00-S-323 sht.03</td><td>Schematic diagram of ICCP station 3 @ KM 00+000 (At PS3)</td></tr><tr><td>70-YF00-S-323 sht.04</td><td>Schematic diagram of ICCP station 4 @ KM 116+460 (At HPT)</td></tr></tbody></table>								DRAWING NO	DRAWING TITLE	70-YF00-S-322 sht. 01	ICCP System overall layout for Pipelines	70-YF00-S-322 sht. 02	ICCP station 1 Layout- @ KM 00+000 (At PS1)	70-YF00-S-322 sht. 03	ICCP station 2 Layout- @ KM 00+000 (At PS2)	70-YF00-S-322 sht. 04	ICCP station 3 Layout- @ KM 00+000 (At PS3)	70-YF00-S-322 sht. 05	ICCP station 4 Layout- @ KM 116+460 (At HPT)	70-YF00-S-323 sht.01	Schematic diagram of ICCP station 1 @ KM 00+000 (At PS1)	70-YF00-S-323 sht.02	Schematic diagram of ICCP station 2 @ KM 00+000 (At PS2)	70-YF00-S-323 sht.03	Schematic diagram of ICCP station 3 @ KM 00+000 (At PS3)	70-YF00-S-323 sht.04	Schematic diagram of ICCP station 4 @ KM 116+460 (At HPT)
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	70-YF00-S-324 sht.03		Deep Anode Bed Installation Details- ICCP station 3 @ KM 00+000 (At PS3)					
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<div>3.DESIGN BASIS</div>								
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<p>3.1 Design Approach & Brief Description</p> <p>The pipelines under B1 & B2 package (see table 1) will be protected permanently through Impressed Current Cathodic Protection Systems (ICCP) using remote anode ground beds.</p> <p>The new pipelines are provided with a temporary CP system (using Mg anodes) until the permanent CP system is commissioned.TCP anodes will be disconnected prior to permanent CP commissioning.</p> <p>The ICCP system for pipelines will consist of ICCP stations installed at four locations (at stations PS1, PS2, PS3 & HPT)^{SEE NOTE} along with the pipeline. The locations are selected considering power availability,land availability,soil resistivity and pipeline attenuation characteristics.</p> <p>Resistivity was measured at all ICCP proposed anode locations.Remote deep anode bed is proposed at locations of PS-1, PS2, PS-3 & HPT stations. see section 8 for resistivity data).</p> <p>New Pipelines shall be electrically isolated from station piping, grounding and other buried metallic structures.</p> <p>The Total current required to protect pipelines of B1 & B2 package is 86.215A. Additional 15% (12.93A) of design current is considered for leakages.So the total current requirement will be 99.147A. The CPTR rating shall be 3 times the design current as per E16. Hence the TR capacity(total) needed will be $3 \times 99.147= 297.44A$.This amount of current will be discharged from four CP stations. One (1) ICCP station rated 30V/100A installed at PS1 station , one (1) ICCP station with 100V/100A at PS2 station, one (1) ICCP station with 100V/50A at PS3 station & one (1) ICCP station with 100V/50A at HPT station along the B1 & B2 Package pipeline.</p> <p>In order to ensure whether the chosen locations are adequate to provide protection along the whole length of pipeline, an attenuation calculatuion^{SEE NOTE} is provided in section 5.6.</p> <p>All cable connections to pipe will be provided by using pin brazing.</p> <p>See sec 5 of the document for calculations. Also see drawings listed in sec 2.3 for more installation details.</p> <p><u>Note:</u> <u>At the time of commissioning or monitoring,if required,additional CP system in between the proposed to be added or new Mg anodes to be added.</u></p> <p><u>The existing pipelines from PS2 to PS3 (140km approximately)are protected well by CP systems installed at both ends(PS2 and PS3).See appendix 2 for survey report. Hence it is expected that the new pipelines will also be protected by CP stations installed at both ends</u></p>								
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Table 2: proposed ICCP Station summary

G/B no.	No. Of GB's	Location (KM)	Type	No. of Anodes-Type	Design Current including leakage(A)	TR capacity (3x design current) (A)	T/R Rating (Volts/Amps.)
GB-1	1	PS-1	Deep Vertical	10-MMO	33.33	100	30V/100A
GB-2	2	PS-2	Deep Vertical	5-MMO	33.33	100	100V/100A
GB-3				5-MMO			
GB-4	2	PS-3	Deep Vertical	18-MMO	16.66	50	100V/50A
GB-5				18-MMO			
GB-6	2	HPT	Deep Vertical	18-MMO	15.82	47.5	100V/50A
GB-7				18-MMO			
Total design Current Required including leakage(A)					99.14	297.5	

3.2 PROTECTION CRITERIA

As per SWCC cathodic protection specification "E16":

The impressed current cathodic protection systems shall be designed to provide sufficient current to achieve an "OFF" potential over the equipment and/or material to be protected, equal to or more negative than – 1 V (measured against a Cu/CuSO₄ reference electrode). "OFF" potentials with a value more negative than – 1.5 V should be avoided

3.3 CURRENT DENSITY

Pipelines are coated with 3 Layer HDPE coating.

As per SWCC standard E16, "for calculations of the permanent CP system a current density of 0.015 mA/m² shall be considered".

Hence a current density of 0.015 mA/m² will be used in this design.

3.4 DESIGN LIFE

As per SWCC standard E16, The service life time of the cathodic protection systems shall not be less than fifty (50) years. For anode groundbeds a life time of twenty five (25) years will be accepted.

The minimum design life time for anode bed will be 25 years.

3.5 SOIL RESISTIVITY

At proposed ICCP stations, resistivity is measured for surface and deep configuration by using four pin soil resistivity device.

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<p>The resistivity data is provided in section 8.</p> <p>The resistivity values to be used in design calculation are summarized in below table.</p> <p>Table 3: Average Soil Resistivity</p> <table><tr><th>Station No.</th><th>Station Location</th><th>Soil Layer (M)</th><th>Soil Resistivity (Ω-Cm)</th></tr><tr><td>1</td><td>PS-1</td><td>30-60m</td><td>377</td></tr><tr><td>2</td><td>PS-2</td><td>30-60m</td><td>5107</td></tr><tr><td>2</td><td>PS-3</td><td>30-90m</td><td>48432</td></tr><tr><td>2</td><td>HPT</td><td>30-90m</td><td>40749</td></tr></table> <p>3.6 ELECTRICAL ISOLATION</p> <p>The pipelines shall be electrically isolated from station piping by means of isolation joints/coupling. If the pipeline is not internally coated with a dielectric material, internal coating shall be provided for 6 M on both sides of isolation joint/fitting to avoid internal corrosion at isolation joints. The pipeline shall be electrically isolated from any other buried metallic structure at any location along the pipeline. Station piping shall be electrically isolated from cross country pipelines at plant entry/exit point. Pipelines shall be electrically isolated from grounded valves as well.</p> <p>Grounding connections on the pipeline shall be performed via special DC Decoupling devices(PCR) avoiding direct DC low-ohmic earthing connections of the pipes. DC decoupling shall have the following characteristics as per E16 sec 9.4</p> <ul style="list-style-type: none">○ DC voltage blocking level – 3/ + 1 V,○ AC rms steady-state current rating 40 A,○ AC rms fault current 9 kA for 0.5 sec.,○ lightning surge current rating (8/20) 100 kA. <p>In palace area, the inlet valve shaft, flow meter shaft and tap off shaft 1 are before isolation coupling and hence grounding connections shall be through PCR.</p> <table><tr><th>S.No</th><th>Pipeline name</th><th>Location</th><th>Chainage (km)</th><th>Reference drawing</th></tr><tr><td>1</td><td rowspan="2">PS1-PS2 Pipeline</td><td>PS1Station</td><td>00+000</td><td>70-YF00-S-309 Page 01</td></tr><tr><td>2</td><td>PS2 Station</td><td>169+729</td><td>70-YF00-S-309 Page 01</td></tr><tr><td>3</td><td rowspan="2">PS2-LV3 Pipeline</td><td>PS2 Station</td><td>00+000</td><td>70-YF00-S-309 Page 01</td></tr><tr><td>4</td><td>LV3 Station</td><td>45+455</td><td>70-YF00-S-309 Page 01</td></tr><tr><td>5</td><td rowspan="2">LV3- PS3 Pipeline</td><td>LV3 Station</td><td>00+000</td><td>70-YF00-S-316 Page 01</td></tr><tr><td>6</td><td>PS3 Station</td><td>80+230</td><td>70-YF00-S-316 Page 01</td></tr><tr><td>7</td><td>PS3- HPT Pipeline</td><td>PS3 Station</td><td>00+000</td><td>70-YF00-S-316 Page 01</td></tr></table>									Station No.	Station Location	Soil Layer (M)	Soil Resistivity (Ω-Cm)	1	PS-1	30-60m	377	2	PS-2	30-60m	5107	2	PS-3	30-90m	48432	2	HPT	30-90m	40749	S.No	Pipeline name	Location	Chainage (km)	Reference drawing	1	PS1-PS2 Pipeline	PS1Station	00+000	70-YF00-S-309 Page 01	2	PS2 Station	169+729	70-YF00-S-309 Page 01	3	PS2-LV3 Pipeline	PS2 Station	00+000	70-YF00-S-309 Page 01	4	LV3 Station	45+455	70-YF00-S-309 Page 01	5	LV3- PS3 Pipeline	LV3 Station	00+000	70-YF00-S-316 Page 01	6	PS3 Station	80+230	70-YF00-S-316 Page 01	7	PS3- HPT Pipeline	PS3 Station	00+000	70-YF00-S-316 Page 01
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<table><tr><td>8</td><td></td><td>HPT Station</td><td>111+647</td><td>70-YF00-S-316 Page 01</td></tr><tr><td>9</td><td rowspan="2">HPT(A/B)- HPT(C)</td><td>HPT(A/B) station</td><td>00+000</td><td>70-YF00-S-316 Page 03</td></tr><tr><td>10</td><td>HPT(C) station</td><td>04+985</td><td>70-YF00-S-316 Page 02</td></tr></table>									8		HPT Station	111+647	70-YF00-S-316 Page 01	9	HPT(A/B)- HPT(C)	HPT(A/B) station	00+000	70-YF00-S-316 Page 03	10	HPT(C) station	04+985	70-YF00-S-316 Page 02						
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10		HPT(C) station	04+985	70-YF00-S-316 Page 02																								
<h3>3.7 Remote Anode to Pipeline Spacing</h3> <p>All the anode beds will be located at a distance of minimum 100 meters from pipelines, which is complying with the E-16 standard.</p> <p>Table 4: Anode Beds Remoteness and Power Source</p> <table><tr><th>Ground bed</th><th>Location</th><th>Co ordinates</th><th>Distance between ground bed & pipeline (M)</th></tr><tr><td>GB-1</td><td>PS1</td><td>E-379276.109 N-2974123.793</td><td>150</td></tr><tr><td>GB-2 & 3</td><td>PS2</td><td>E-220954.632 N-2957668.264 E-220986.7073 N-2957617.3699</td><td>150</td></tr><tr><td>GB-4 & 5</td><td>PS3</td><td>E-749807.8974 N-2855192.5919 E-749859.0396 N-2855161.2192</td><td>150</td></tr><tr><td>GB-6 & 7</td><td>HPT</td><td>E-702797.12 N-2759934.48 E-702851.36 N-2759958.42</td><td>150</td></tr></table> <p><i>Note: Anode bed locations are proposed in drawings 70-YF00-S-322 sheet 1 to 5. Anode bed locations and right of way to be confirmed by RTCC.</i></p> <h3>3.8 Monitoring</h3> <h4>Local monitoring</h4> <p>Test stations and bond boxes installed along with TCP will be retained and utilized for permanent CP.</p> <p>One current test station will be provided at ICCP drain points. Coupon and RE Test stations will be installed at mid point of ICCP stations. The potential test station installed under TCP at PTS-17 ,PTS -34 , PTS-51 (B1 package) & PTS-7(B2 package), PTS-54(B2 package) will be upgraded with coupons and Reference electrode. Transdurer will be provided with coupon test station.</p>									Ground bed	Location	Co ordinates	Distance between ground bed & pipeline (M)	GB-1	PS1	E-379276.109 N-2974123.793	150	GB-2 & 3	PS2	E-220954.632 N-2957668.264 E-220986.7073 N-2957617.3699	150	GB-4 & 5	PS3	E-749807.8974 N-2855192.5919 E-749859.0396 N-2855161.2192	150	GB-6 & 7	HPT	E-702797.12 N-2759934.48 E-702851.36 N-2759958.42	150
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<p><u>Remote Monitoring System</u></p> <p>RMU facility will be provided for each pipeline ICCP station. RMU will have a built in current interrupter. The RMU will be installed in TR enclosure.</p> <p>The RMU will send the signal to DCS/SCADA through RS485 communication</p> <p>The monitored parameters will be,</p> <ul style="list-style-type: none">- AC input status of TR- DC output voltage of TR- DC output current of TR (across shunt (mV))- Structure potential <p>The structure potential channel will be used to make low potential alarm by configuring DCS/SCADA with necessary time delay.</p> <p>Two permanent Copper –copper sulphate reference electrode (Borin-STELTH 2 SRE-007-CUY) or Ag/Agcl reference (Borin-STELTH 2 SRE-008-SUB)electrode suitable for underground applications will be installed at each ICCP station 0.2 m from piping for monitoring structure potential. Reference electrode tail cable (1C x 6mm2 HMWPE) will be routed towards the RMU and will be terminated inside RMU. One 2C x 2.5mm2 HMWPE monitoring cable will be connected to piping by means of pin brazing from one side and the other end will be terminated in RMU to enable remote potential monitoring with respect to the stationary electrode.</p> <p>The RMU is provided with a GPS synchronized Timer by default in which the timer clock is set with respect to GPS clock, in order to maintain same on/off cycle for all other TRs (to avoid overlapping of switching during interruption).</p> <p>Communication cabling between RMU and RTU/DCS/SCADA is beyond CP vendor scope.</p> <p>Note :</p> <p>1. Ag-AgCl RE will be installed where resistivity is below 500 ohm-cm</p>								
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<div>4.MATERIAL SELECTION</div>								
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<div>4.1 TRANSFORMER RECTIFIER</div> <div><div><div><div><div></div><div>Transformer Rectifier Model</div></div><div>:</div><div>Conventional (Manual)</div></div><div><div><div></div><div>Control Type</div></div><div>:</div><div>Tap adjustable (link bar)</div></div><div><div><div></div><div>Cooling Class</div></div><div>:</div><div>Class ONAN (Oil Immersed Air Cooled)</div></div><div><div><div></div><div>AC input</div></div><div>:</div><div>1-Phase, 230V, 60Hz</div></div><div><div><div></div><div>DC output</div></div><div>:</div><div>100V/100A,100V/50A,30V/100A</div></div><div><div><div></div><div>Weather Protection</div></div><div>:</div><div>IP 65 (NEMA 4X)</div></div><div><div><div></div><div>Enclosure Type & Coating</div></div><div>:</div><div>Hot Dip Galvanized Enclosure</div></div><div><div><div></div><div>Area Classification</div></div><div>:</div><div>Non-Hazardous</div></div><div><div><div></div><div>Installation</div></div><div>:</div><div>Concrete pad</div></div><div><div><div></div><div>Remote monitoring provision</div></div><div>:</div><div>Included with TR**</div></div></div></div> <div>**Following signals can be monitored through built-in Remote monitoring system.</div> <div><div><div><div></div><div>AC input status</div></div><div>:</div><div>Digital</div></div><div><div><div></div><div>DC output voltage of TR</div></div><div>:</div><div>Analogue</div></div><div><div><div></div><div>DC output current of TR (across shunt (mV)</div></div><div>:</div><div>Analogue</div></div><div><div><div></div><div>Structure potential</div></div><div>:</div><div>Analogue</div></div></div> <div>RMU can be hard wired to DCS/SCADA system (communication cabling is beyond CP vendor scope).</div> <div>Note : We are trying to get limiting indication device option from TR manufacture. After getting confirmation from Manufacturer, we will include the details in MS.</div> <div>4.2 ANODES</div> <div>Anodes for ICCP systems at PS-1 & PS-2 stations</div> <div><div><div><div><div></div><div>Anode Type</div></div><div>:</div><div>MMO Tubular</div></div><div><div><div></div><div>Application</div></div><div>:</div><div>Soil/Calcined Petroleum Backfill</div></div><div><div><div></div><div>Working Environment</div></div><div>:</div><div>Evolution O2, Cl2 or both</div></div><div><div><div></div><div>Length</div></div><div>:</div><div>122 Cm</div></div><div><div><div></div><div>Diameter</div></div><div>:</div><div>3.18 Cm</div></div><div><div><div></div><div>Substrate</div></div><div>:</div><div>Titanium- ASTM B338 grade 1 or grade 2.</div></div><div><div><div></div><div>Anode Current Output</div></div><div>:</div><div>9.6 A (for 25 years)</div></div><div><div><div></div><div>Design Life</div></div><div>:</div><div>25 years (when operating @ 9.6 A)</div></div><div><div><div></div><div>Tail cable</div></div><div>:</div><div>1C x 16mm2, Cu, HMWPE</div></div><div><div><div></div><div>Anode backfill</div></div><div>:</div><div>Calcined petroleum coke</div></div></div></div> <div>Anodes for ICCP systems at PS-3 & HPT stations</div> <div><div><div><div><div></div><div>Anode Type</div></div><div>:</div><div>MMO Tubular</div></div><div><div><div></div><div>Length</div></div><div>:</div><div>1000mm</div></div><div><div><div></div><div>Diameter</div></div><div>:</div><div>19mm</div></div></div></div> <tr><td colspan="3">Final Engineering</td><td colspan="3">Contractor</td><td colspan="3">Subcontractor</td></tr> <tr><td colspan="3">ILF</td><td colspan="3">Al-Rashid Trading & Contracting Co.</td><td colspan="3">SOGEC</td></tr>									Final Engineering			Contractor			Subcontractor			ILF			Al-Rashid Trading & Contracting Co.			SOGEC		
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<div><div><div><div><div></div><div>Current Output</div><div>: 1.6 A</div></div><div><div></div><div>Design Life</div><div>: 25 years</div></div><div><div></div><div>Tail cable</div><div>: 1C x 10mm2, Cu, HMWPE</div></div><div><div></div><div>Anode backfill</div><div>: Calcined petroleum coke</div></div></div></div><div><div>4.3</div><div>CABLES</div><div><div><div></div><div>Anode tail cables will be 1C x 16mm² , 1C x 10mm² Cu, HMWPE.</div></div><div><div></div><div>Positive branch cables will be 1C x 35mm², Cu, HMWPE.</div></div><div><div></div><div>Main positive cables will be 1C x 50mm², Cu, HMWPE.</div></div><div><div></div><div>Negative branch Cables will be 1C x 25mm² or 35mm² or 50mm2 Cu, HMWPE.</div></div><div><div></div><div>Main negative cables will be 1C x 50mm², Cu, HMWPE.</div></div><div><div></div><div>Measuring cable will be 2C x 2.5 mm², Cu, HMWPE.</div></div><div><div></div><div>RE cable will be 1C x 6 mm², Cu, HMWPE.</div></div><div><div></div><div>Test Coupon cable 2C x 2.5 mm², Cu, HMWPE.</div></div></div></div><div><div>(All the cables comply with National Fire Protection Association NFPA 70, National Electric Code)</div></div><div><div>4.4</div><div>JUNCTION BOX</div><div><div><div></div><div>Types</div><div>: AJB, NJB,MPJB,MNJB</div></div><div><div></div><div>Number of terminals</div><div>: 3, 6,12,20 & 20</div></div><div><div></div><div>Shunt</div><div>: 50mV/50A</div></div><div><div></div><div>Variable resistor</div><div>: 3 ohm/100W(Provision in all JB, except in AJB)</div></div><div><div></div><div>Weather Protection</div><div>: NEMA 4X (IP 65)</div></div><div><div></div><div>Enclosure Type & Coating</div><div>: Aluminum, powder coated</div></div><div><div></div><div>Area Classification</div><div>: Non-Hazardous</div></div><div><div></div><div>Installation</div><div>: Steel supports with Concrete pad</div></div></div></div><div><div>4.5</div><div>TEST STATION</div><div><div><div></div><div>Number of terminals</div><div>: 8 Terminal</div></div><div><div></div><div>Size</div><div>: 3"</div></div><div><div></div><div>Weather Protection</div><div>:Weather proof</div></div><div><div></div><div>Enclosure</div><div>:Polycarbonate</div></div><div><div></div><div>Area Classification</div><div>:Non-Hazardous</div></div><div><div></div><div>Installation</div><div>:3" HDG pipe support with Concrete pad</div></div><div><div></div><div>Additional Accessories(@ coupon location) : RE,CP coupon, Magnetic reed/toggle switch.</div></div></div></div><div><div>4.6</div><div>PERMANENT REFERENCE ELECTRODE</div><div><div><div></div><div>Type</div><div>:Cu/CuSO₄ (Borin Stealth-2, SRE-007-CUY) & Ag/Agcl (Borin Stealth-2, SRE-008-SUB)</div></div><div><div></div><div>Lead wire</div><div>:1C x 6 mm², Cu, HMWPE.</div></div></div></div></div>								
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<p>Note :Ag-AgCl RE will be installed where resistivity is below 500 ohm-cm</p> <p>4.7 TEST COUPON</p> <ul style="list-style-type: none">○ Material :Carbon steel○ Sensing area :10cm2○ Tail cable :2 x 2.5 mm², HMWPE 12m long <p>4.8 COATING REPAIR</p> <ul style="list-style-type: none">○ Type :Melt stick epoxy○ Model :Nap-Gard 7-1631S “E-Z” stick○ Material :Polyamide based thermoplastic repair material○ Area of application :Coating repair at weld area								
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<div>5.1 SURFACE AREA & CURRENT REQUIREMENT CALCULATIONS</div> <p>The pipelines of B1 & B2 Packages will be protected permanently by Impressed Current Cathodic Protection Systems (ICCP) using remote deep anode ground beds.</p> <p>The Impressed Current Cathodic Protection System (ICCP) consists of four (4) CP stations installed at PS1,PS2,PS3 & HPT along with the pipeline.</p> <p>The surface area is calculated using the formula of:</p> <div>A = π x D x L</div> <div>Where, A = area of the pipeline (m2). D = pipeline diameter (m). L = pipeline length (m)</div> <p>The current required for ICCP is calculated using the formula,</p> <div>I = A x (i/1000)</div> <div>Where I = required current (A) A = total area of the pipeline (m2) i = current density (0.015mA/m2 as per E16)</div> <p>Current requirement is summarized in below Table.</p> <div>Table 5: Pipeline current required table</div> <table><tr><th>Serial No.</th><th>Pipeline</th><th>No. of P/L's</th><th>System Type</th><th>L_p:Length (m)</th><th>D_p:Diameter (m)</th><th>A: Surface Area (m²)</th><th>i: Current Density (mA/m²)</th><th>I_r: Current Required (A)</th></tr><tr><td>1</td><td>PS1-PS2</td><td>2</td><td>ICCP</td><td>169729</td><td>2.2352</td><td>2383703.91</td><td>0.015</td><td>35.7556</td></tr><tr><td>2</td><td>PS2-LV3</td><td>2</td><td>ICCP</td><td>45455</td><td>2.2352</td><td>638378.01</td><td>0.015</td><td>9.5757</td></tr><tr><td>3</td><td>LV3 to PS3</td><td>2</td><td>ICCP</td><td>80230</td><td>2.2352</td><td>1126764.22</td><td>0.015</td><td>16.9015</td></tr><tr><td>4</td><td>PS3 to HPT</td><td>2</td><td>ICCP</td><td>111647</td><td>2.2352</td><td>1567990.10</td><td>0.015</td><td>23.5199</td></tr></table>									Serial No.	Pipeline	No. of P/L's	System Type	L _p :Length (m)	D _p :Diameter (m)	A: Surface Area (m²)	i: Current Density (mA/m²)	I _r : Current Required (A)	1	PS1-PS2	2	ICCP	169729	2.2352	2383703.91	0.015	35.7556	2	PS2-LV3	2	ICCP	45455	2.2352	638378.01	0.015	9.5757	3	LV3 to PS3	2	ICCP	80230	2.2352	1126764.22	0.015	16.9015	4	PS3 to HPT	2	ICCP	111647	2.2352	1567990.10	0.015	23.5199
Serial No.	Pipeline	No. of P/L's	System Type	L _p :Length (m)	D _p :Diameter (m)	A: Surface Area (m²)	i: Current Density (mA/m²)	I _r : Current Required (A)																																													
1	PS1-PS2	2	ICCP	169729	2.2352	2383703.91	0.015	35.7556																																													
2	PS2-LV3	2	ICCP	45455	2.2352	638378.01	0.015	9.5757																																													
3	LV3 to PS3	2	ICCP	80230	2.2352	1126764.22	0.015	16.9015																																													
4	PS3 to HPT	2	ICCP	111647	2.2352	1567990.10	0.015	23.5199																																													
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<table><tr><td rowspan="2">5</td><td rowspan="2">HPT/C to HPT/A+B</td><td>1</td><td>ICCP</td><td>622</td><td>1.524</td><td>2978.00</td><td>0.015</td><td>0.0447</td></tr><tr><td>1</td><td>ICCP</td><td>4363</td><td>2.032</td><td>27852.15</td><td>0.015</td><td>0.4178</td></tr><tr><td colspan="8">I_R: Total Current Required</td><td>86.215</td></tr><tr><td colspan="8">Spare for leakage (15%)</td><td>12.932</td></tr><tr><td colspan="8">Total design Current Required including leakage(A)</td><td>99.147</td></tr><tr><td colspan="8">Calculated TR Rating as per E16 (300%)</td><td>297.44</td></tr></table>									5	HPT/C to HPT/A+B	1	ICCP	622	1.524	2978.00	0.015	0.0447	1	ICCP	4363	2.032	27852.15	0.015	0.4178	I _R : Total Current Required								86.215	Spare for leakage (15%)								12.932	Total design Current Required including leakage(A)								99.147	Calculated TR Rating as per E16 (300%)								297.44
5	HPT/C to HPT/A+B	1	ICCP	622	1.524	2978.00	0.015	0.0447																																																				
		1	ICCP	4363	2.032	27852.15	0.015	0.4178																																																				
I _R : Total Current Required								86.215																																																				
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Total design Current Required including leakage(A)								99.147																																																				
Calculated TR Rating as per E16 (300%)								297.44																																																				
<p>The current required to protect the new pipelines is 86.215 A. Additional 15 % of current (12.93A) is considered for leakages. So the total current requirement will be 99.147 A.</p> <p>The CPTR rating shall have 3 times design current capacity as per E16. Hence the total TR capacity needed will be 3 x 99.147= 297.44 A.This current will be discharged from four (4) ICCP stations. Each TR capacity required is 100A ,100A,50A & 50A.</p> <p>5.2 ICCP Station 1 @ KM 00+000(At PS1 at Jubail)</p> <p>5.2.1 ICCP Station-1 Description</p> <p>The area is Subkha and the resistivity changes with depth(see section 8). Remote deep vertical anode bed is proposed at this location with 10 no's of MMO tubular anodes. Anodes will be installed at 30 to 73m depth and min.100m away from pipelines. Each Anode tail cable will be terminated in a common 12 terminal junction box. Anode tail cable sizes will be 1C x 16mm²,HMWPE.The anode bed will be powered by a 30V/100A rectifier. A 1Cx 25 mm² HMWPE negative cable will be installed for two pipelines and it will be terminated in 3T NJB. A 1Cx50mm² cable will be installed between pipeline and TR negative terminal. A 1Cx50mm²HMWPE positive cable will be installed between 12T AJB and TR positive terminal. Negative cable will be connected to pipeline using pin brazing.TR will be provided with remote monitoring unit. The two permanent Ag-Agcl reference electrode will be installed at drain point to monitor structure potential. A monitoring cable(2Cx2.5mm²) will be connected to pipeline one end using pin brazing. The other end of monitoring cable and RE cable(1Cx6mm²) will be terminated in RMU.</p> <p>5.2.2 ICCP Current Requirement</p> <table><tr><th colspan="7">Table 6:Current Requirement</th></tr><tr><th>Pipeline Name</th><th>No. of P/L's</th><th>Dia (M)</th><th>Coverage Length (M)</th><th>Area for two pipeline (M²)</th><th>Current Density (mA/m²)</th><th>Current Required (A)</th></tr><tr><td>PS1 to PS2 (P1)</td><td>2</td><td>2.2352</td><td>137590</td><td>1932338</td><td>0.015</td><td>28.99</td></tr></table>									Table 6:Current Requirement							Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M ²)	Current Density (mA/m ²)	Current Required (A)	PS1 to PS2 (P1)	2	2.2352	137590	1932338	0.015	28.99																															
Table 6:Current Requirement																																																												
Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M ²)	Current Density (mA/m ²)	Current Required (A)																																																						
PS1 to PS2 (P1)	2	2.2352	137590	1932338	0.015	28.99																																																						
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Current Required for new pipelines (A)	28.99
Spare for leakage (15%)	4.35
Total design Current Required including leakage, I_T(A)	33.33
3 Times design current as per E16	100
TR Current rated Proposed (A)	100
TR voltage rating Proposed (V)	30

5.2.3 Quantity of Anodes Required

Table 6: Anode Quantity Required			
	Anode Type	MMO Tubular	
	Anode Length	122	cm
	Anode diameter	2.5	cm
I _a	Single anode current(for 25 years)	9.6	A
I _T	Total design current including spare	33.33	A
N	Number of anode = I_T/I_a	4	Each
Number of anode chosen		10	Each

Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.

5.2.4 Total Ground bed resistance

Table 8:Anodebed Resistance		
$R_G = \left[\frac{\rho}{2 \pi x L_a} \right] \left[Ln \left(\frac{8xL_a}{D_a} \right) - 1 \right]$		
	Anode configuration**	Deep-Remote vertical
	Installation start depth from grade level (CM)	3000
	Anode length (CM)	122
	Total Number of Anode Holes	1
	Coke coverage above anode (CM)	300
	Coke coverage below anode (CM)	150

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	Anode end to end spacing (CM)	300
p	soil resistivity (ohm-cm)	377
La	Anode bed active column length (CM)	4370
Da	Anode bed active column Diameter (CM)	25.4
N	Number of anode per hole (Each)	10
RG	Anode bed resistance (ohms)	0.0855

***Final anode configuration and depth may be changed to cope up with actual site conditions while drilling.*

5.2.5 Total Cable resistance

Total cable resistance includes the effective resistance of all single cables in parallel or series with the CP circuit.

Single Cable Resistance = Cable length x Unit Cable resistance

Unit resistances of commonly used CP cable are below.

Table 7: Cable resistances

Cable Size	Resistance in ohm per Meter
16 mm ²	0.001673
25 mm ²	0.001053
35 mm ²	0.000659
50 mm ²	0.000417
70 mm ²	0.000331
95 mm ²	0.000261
120 mm ²	0.000205
185 mm ²	0.000125

The cables resistance will be calculated as follows:

$$R_c = R_{ctT} + R_{cpT} + R_{cdT} + R_{cnT}$$

Where,

R_c = Total Cable resistance (Ohm)

R_{ctT} = Parallel resistance of all anode tail cables (Ohm)

R_{cdT} = Parallel resistance of all drain cables (Ohm)

R_{cpT} = resistance of positive cable (Ohm)

R_{cnT} = resistance of negative cable (Ohm)

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Table 10:Cable resistance

Cable From	Cable To	New/Existi ng	Cable ID	Details			
				size	L: Cable Length (m)	r: Cable resistanc e per meter (Ω/m)	Cable Resistanc e (Ω)
Anode 1	12T AJB	New	A1	16mm²	49	0.001673	0.0820
Anode 2		New	A2	16mm²	53	0.001673	0.0887
Anode 3		New	A3	16mm²	57	0.001673	0.0954
Anode 4		New	A4	16mm²	61	0.001673	0.1021
Anode 5		New	A5	16mm²	65	0.001673	0.1087
Anode 6		New	A6	16mm²	69	0.001673	0.1154
Anode 7		New	A7	16mm²	73	0.001673	0.1221
Anode 8		New	A8	16mm²	77	0.001673	0.1288
Anode 9		New	A9	16mm²	81	0.001673	0.1355
Anode 10		New	A10	16mm²	85	0.001673	0.1422
Anode tail cable parallel resistance,RctT=							0.0109
TR	12 AJB	New	(RcpT)	50mm²	200	0.000417	0.0834
Pipeline (P1)	3T NJB	New	(Rcd1)	25mm²	45	0.001053	0.0474
Pipeline (P2)	3T NJB	New	(Rcd2)	25mm²	20	0.001053	0.0211
Negative drain cable parallel resistance,RcdT=							0.0146
TR	3 NJB	New	(RncT)	50mm²	140	0.000417	0.0584
RcT: Total Cable resistance(RctT + RcpT + RcdT+ RcnT)=							0.1672

5.2.6 Total Circuit Resistance

Table 11:Total circuit resistance

RG	Anode resistance	0.0855	ohms
Rc	Cable resistance	0.1672	ohms
RT	Total circuit resistance(RG + Rc)	0.2527	ohms

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5.2.7 TR voltage required

Table 12: Minimum TR voltage required

RT	Total circuit resistance	0.2527	ohms
I	Design current (Including Spare)	33.33	A
emf	Back emf	2	V
V	TR Min voltage Required =(RTx I)+2 =	10.42	V
E	TR rated voltage Chosen	30	V

5.2.8 TR AC power requirement

Table 13:TR AC power requirement

Ir	TR DC rated current	100	A
E	TR DC rated Voltage	30	V
Eac	AC input voltage	230	V
	AC input phase	1	-
Eff	Efficiency	80	%
Pf	Power factor	0.8	
VA	AC input VA=(E x Ir)/(Eff x pf)	4687.5	VA
Iac	AC input current=VA/Eac	20.380	A

5.2.9 Design life for Proposed Anode Qty

Single Anode Output = 9.6 A (For 25 Years)
 Total No's of Anodes Proposed for this ICCP stations = 10 Anodes
 Total Anodes output = 10 * 9.6 = 96A (For 25 Years)
 Total design current required including spare leakage (15%) = 33.33A
 Hence,
 Anode lifetime when operating at total design current (33.33A) will be
 = (25 * 96)/33.33
 = **72.00 Years**

So the calculated anode lifetime exceeds 50 years and complies with E16 Section 9.2.1.

Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.

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<div>5.3 ICCP Station 2 @ KM 00+000(At PS2 station)</div> <div>5.3.1ICCP Station-2 Description</div> <p>The resistivity changes with depth(see section 8). Remote deep vertical anode bed is proposed at this location with 5 no's of MMO tubular anodes in two deep anode bed configuration. Anodes will be installed at 30 to 52m depth and min.100m away from pipelines. Each Anode tail cable will be terminated in a common 6 terminal junction box. Anode tail cable sizes will be 1C x 16mm2,HMWPE.The anode bed will be powered by a 100V/100A rectifier.Three terminal NJBs will be installed near to upstream and down stream of twin pipelines at plant entry/exit.These NJBs will be further connected to MNJB located near TR using 1Cx 35/50 mm2 HMWPE cables. 1Cx 25 mm2 HMWPE negative cable will be installed for twin pipelines at two different location and it will be terminated in 2T NJB(2nos.). 1Cx50mm2 cable will be installed between 3T MNJB and TR negative terminal. A 1Cx35mm2 HMWPE positive cable will be installed between 6T JB and 3T multi-purpose positive Junction box.Then 1Cx50mm2 HMWPE Main positive cable will be installed between 3T MPJB and Positive terminal of the TR.The Negative cable will be connected to pipeline using pin brazing.TR will be provided with remote monitoring unit. The two permanent copper -copper sulphate reference electrode and will be installed at drain point to monitor structure potential. A monitoring cable(2Cx2.5mm2) will be connected to pipeline one end using pin brazing. The other end of monitoring cable and RE cable(1Cx6mm2) will be terminated in RMU.</p> <div>5.3.2 ICCP Current Requirement</div> <table><tr><th colspan="7">Table 13:Current Requirement</th></tr><tr><th>Pipeline Name</th><th>No. of P/L's</th><th>Dia (M)</th><th>Coverage Length (M)</th><th>Area for two pipeline (M²)</th><th>Current Density (mA/m²)</th><th>Current Required (A)</th></tr><tr><td>PS1 to PS2 to LV3</td><td>2</td><td>2.2352</td><td>137590</td><td>1932338</td><td>0.015</td><td>28.99</td></tr><tr><td colspan="6">Current Required for new pipelines (A)</td><td>28.99</td></tr><tr><td colspan="6">Spare for leakage (15%)</td><td>4.35</td></tr><tr><td colspan="6">Total design Current Required including leakage,I_T(A)</td><td>33.33</td></tr><tr><td colspan="6">3 Times design current as per E16</td><td>100</td></tr><tr><td colspan="6">TR Current rated Proposed (A)</td><td>100</td></tr><tr><td colspan="6">TR voltage rating Proposed (V)</td><td>100</td></tr></table> <div>5.3.3 Quantity of Anodes Required</div>									Table 13:Current Requirement							Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M²)	Current Density (mA/m²)	Current Required (A)	PS1 to PS2 to LV3	2	2.2352	137590	1932338	0.015	28.99	Current Required for new pipelines (A)						28.99	Spare for leakage (15%)						4.35	Total design Current Required including leakage,I _T (A)						33.33	3 Times design current as per E16						100	TR Current rated Proposed (A)						100	TR voltage rating Proposed (V)						100
Table 13:Current Requirement																																																																							
Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M²)	Current Density (mA/m²)	Current Required (A)																																																																	
PS1 to PS2 to LV3	2	2.2352	137590	1932338	0.015	28.99																																																																	
Current Required for new pipelines (A)						28.99																																																																	
Spare for leakage (15%)						4.35																																																																	
Total design Current Required including leakage,I _T (A)						33.33																																																																	
3 Times design current as per E16						100																																																																	
TR Current rated Proposed (A)						100																																																																	
TR voltage rating Proposed (V)						100																																																																	
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Table 15 : Anode Quantity Required

	Anode Type	MMO Tubular	
	Anode Length	122	cm
	Anode diameter	2.5	cm
I _a	Single anode current	9.6	A
I _T	Design current	33.33	A
N	Number of anode = I_T/I_a	4	Each
	Number of anode chosen	10	Each

Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.

5.3.4Total Ground bed resistance

Table 16:Anodebed Resistance

$R_G = \left[\frac{\rho}{2\pi x L_s x N} \right] \left[\ln \left(\frac{8xL_s}{D_s} \right) - 1 + \frac{2x}{5} \ln(0.656 * N) \right]$		
	Anode configuration**	Deep-Remote vertical
	Installation start depth from grade level (CM)	3000
	Anode length (CM)	122
N	Total Number of Anode Holes	2
S	Anode hole spacing(cm)	6000
	Coke coverage above anode (CM)	300
	Coke coverage below anode (CM)	150
	Anode end to end spacing (CM)	300
p	soil resistivity (ohm-cm)	5107
La	Anode bed active column length (CM)	2260
Da	Anode bed active column Diameter (CM)	25.4
	Number of anode per hole (Each)	5

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RG	Total Anode bed resistance (ohms)	1.038
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***Final anode configuration and depth may be changed to cope up with actual site conditions while drilling.*

5.3.5 Total Cable resistance

Total cable resistance includes the effective resistance of all single cables in parallel or series with the CP circuit.

Single Cable Resistance = Cable length x Unit Cable resistance

Unit resistances of commonly used CP cable are below.

Table 17: Cable Resistance

Cable Size	Resistance in ohm per Meter
10 mm ²	0.002654
16 mm ²	0.001673
25 mm ²	0.001053
35 mm ²	0.000659
50 mm ²	0.000417
70 mm ²	0.000331
95 mm ²	0.000261
120 mm ²	0.000205
185 mm ²	0.000125

The cables resistance will be calculated as follows:

$$R_c = R_{ctT} + R_{cbpT} + R_{cpT} + R_{cdT} + R_{cbnT} + R_{cnT}$$

Where,

R_c = Total Cable resistance (Ohm)

R_{ctT} = Parallel resistance of all anode tail cables (Ohm)

R_{cbpT} = Parallel Positive branch cable resistance (Ohm)

R_{cpT} = Resistance of positive cable (Ohm)

R_{cdT} = Parallel drain cables resistance (Ohm)

R_{cbnT} = Parallel negative branch cable resistance (Ohm)

R_{cnT} = resistance of negative cable (Ohm)

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Table 18:Cable resistance

Cable From	Cable To	New/Existing	Cable ID	Details			
				size	L: Cable Length (m)	r: Cable resistance per meter (Ω/m)	Cable Resistance (Ω)
Anode 1	6T AJB-1	New	A1	16mm ²	49	0.001673	0.0820
Anode 2		New	A2	16mm ²	53	0.001673	0.0887
Anode 3		New	A3	16mm ²	57	0.001673	0.0954
Anode 4		New	A4	16mm ²	61	0.001673	0.1021
Anode 5		New	A5	16mm ²	65	0.001673	0.1087
Anode tail cable parallel resistance,RctT1=							0.0189
No. of deep well							2
Total Anode tail cable parallel resistance,RctT=							0.0094
3T MPJB	6T AJB - 1	New	(Rcbp1)	35mm ²	45	0.000659	0.0297
3T MPJB	6T AJB - 2	New	(Rcbp2)	35mm ²	45	0.000659	0.0297
Positive branch cable parallel resistance,RcbpT=							0.0148
TR	3T MPJB	New	(RcpT)	50mm ²	180	0.000417	0.0751
Pipeline (P1)	NJB- 1	New	(Rcd1)	25mm ²	55	0.001053	0.0579
Pipeline (P2)		New	(Rcd2)	25mm ²	15	0.001053	0.0158
Pipeline (P1)	NJB- 2	New	(Rcd1)	25mm ²	55	0.001053	0.0579
Pipeline (P2)		New	(Rcd2)	25mm ²	15	0.001053	0.0158
Negative drain cable parallel resistance,RcdT=							0.0062
NJB-1	3T MNJB	New	(Rcbn1)	35mm ²	120	0.000659	0.0791
NJB-2	3T MNJB	New	(Rcbn2)	50mm ²	550	0.000417	0.2294
Negative branch cable parallel resistance, from NJB to MNJB RcbnT=							0.0588
TR	3T MNJB	New	(RncT)	50mm ²	50	0.000417	0.0209
RcT: Total Cable resistance(RctT + RcbpT +RcpT+ RcdT+ RcbnT+RcnT)=							0.1852

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ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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5.3.6 Total Circuit Resistance

Table 19: Total circuit resistance

RG	Anode resistance	1.0380	ohms
Rc	Cable resistance	0.1852	ohms
RT	Total circuit resistance(RG + Rc)	1.2232	ohms

5.3.7 TR voltage Required

Table 20: Minimum TR voltage required

RT	Total circuit resistance	1.2232	ohms
I	Design current (Including Spare)	33.33	A
emf	Back emf	2	V
V	TR Min voltage Required $= (RT \times I) + 2 =$	42.77	V
E	TR rated voltage Chosen	100	V

5.3.8 TR AC power requirement

Table 21: TR AC power requirement

Ir	TR DC rated current	100	A
E	TR DC rated Voltage	100	V
Eac	AC input voltage	230	V
	AC input phase	1	-
Eff	Efficiency	80	%
Pf	Power factor	0.8	
VA	AC input $VA = (E \times Ir) / (Eff \times pf)$	15625	VA
Iac	AC input current $= VA / Eac$	67.935	A

5.3.9 Design life for Proposed Anode Qty

Single Anode Output = 9.6 A (For 25 Years)
 Total No's of Anodes Proposed for this ICCP stations = 10 Anodes
 Total Anodes output = $10 \times 9.6 = 96A$ (For 25 Years)
 Total design current required including spare leakage (15%) = 33.33A

Hence,
 Anode lifetime when operating at total design current (33.33A) will be $= (25 \times 96) / 33.33$
 $= 72.00$ Years

So the calculated anode lifetime exceeds 50 years and complies with E16 Section 9.2.1.

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ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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<p><i>Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.</i></p> <p>5.4 ICCP Station 3 @ KM 00+000(At PS-3 station)</p> <p>5.4.1 ICCP Station-3 Description</p> <p>The area is rocky and the resistivity changing with depth(see section 8). Remote deep vertical anode bed is proposed at this location. In order to lower anode resistance,18 no's of MMO tubular anodes in two deep anode bed configuration is proposed. Anodes will be installed at 30 to 104m depth and minimum 100m away from pipelines. Each Anode tail cable will be terminated in a common 20 terminal junction box. Anode tail cable sizes will be 1C x 10mm2,HMWPE.The anode bed will be powered by a 100V/50A rectifier.Three terminal NJBs will be installed near to upstream and down stream of twin pipelines at plant entry/exit.These NJBs will be further connected to MNJB located near TR using 1Cx 35mm2 HMWPE cables. A 1Cx 25 mm2 HMWPE negative cable will be installed for each pipelines at two different location and it will be terminated in 3T NJB(2nos.). A 1Cx35mm2 HMWPE negative branch cable will be installed between 3T NJB and 3T multi-purpose Negative Junction box. 1Cx50mm2 cable will be installed between 3T MNJB and TR negative terminal. A 1Cx35mm2 HMWPE positive cable will be installed between 20T JB and 3T multi-purpose positive Junction box.Then 1Cx50mm2 HMWPE Main positive cable will be installed between 3T MPJB and Positive terminal of the TR. The Negative cable will be connected to pipeline using pin brazing.TR will be provided with remote monitoring unit. The two permanent copper -copper sulphate reference electrode and will be installed at drain point to monitor structure potential. A monitoring cable(2Cx2.5mm2) will be connected to pipeline one end using pin brazing. The other end of monitoring cable and RE cable(1Cx6mm2) will be terminated in RMU.</p> <p>5.4.2 ICCP Current Requirement</p> <table><tr><th colspan="7">Table 22:Current Requirement</th></tr><tr><th>Pipeline Name</th><th>No. of P/L's</th><th>Dia (M)</th><th>Coverage Length (M)</th><th>Area for two pipeline (M²)</th><th>Current Density (mA/m²)</th><th>Current Required (A)</th></tr><tr><td>LV3 to PS3 to HPT</td><td>2</td><td>2.2352</td><td>68771</td><td>965832</td><td>0.015</td><td>14.487</td></tr><tr><td colspan="6">Current Required for newpipelines (A)</td><td>14.487</td></tr><tr><td colspan="6">Spare for leakage (15%)</td><td>2.173</td></tr><tr><td colspan="6">Total design Current Required including leakage(A)</td><td>16.66</td></tr><tr><td colspan="6">3 Times design current as per E16</td><td>49.98</td></tr><tr><td colspan="6">TR Current rated Proposed (A)</td><td>50</td></tr></table>									Table 22:Current Requirement							Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M²)	Current Density (mA/m²)	Current Required (A)	LV3 to PS3 to HPT	2	2.2352	68771	965832	0.015	14.487	Current Required for newpipelines (A)						14.487	Spare for leakage (15%)						2.173	Total design Current Required including leakage(A)						16.66	3 Times design current as per E16						49.98	TR Current rated Proposed (A)						50
Table 22:Current Requirement																																																																
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TR voltage rating Proposed (V)	100
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5.4.3 Quantity of Anodes Required

Table 23: Anode Quantity Required

	Anode Type	MMO Tubular	
	Anode Length	100	cm
	Anode diameter	1.9	cm
I _a	Single anode current	1.6	A
I _T	Design Current	16.66	A
N	Number of anode = I _T /I _a	11	Each
	Number of anode chosen (to lower anode resistance)	36	Each

Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.

5.4.4 Total Ground bed resistance

Table 24:Anodebed Resistance

$R_g = \left[\frac{\rho}{2\pi \times L_a \times N} \right] \left[\ln \left(\frac{8 \times L_a}{D_a} \right) - 1 + \frac{2\pi}{5} \ln(0.656 \times N) \right]$		
	Anode configuration	Deep-Remote vertical
	Installation start depth from grade level (CM)	3000
	Anode length (CM)	100
N	Total Number of Anode Holes	2
S	Anode Hole Spacing	6000
	Coke coverage above anode (CM)	300
	Coke coverage below anode (CM)	150
	Anode end to end spacing (CM)	300
p	soil resistivity (ohm-cm)	48432
La	Anode bed active column length (CM)	7350
Da	Anode bed active column Diameter (CM)	25.4
	Number of anode per hole (Each)	18

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RG	Total Anode bed resistance (ohms)	3.8868
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***Final anode configuration and depth may be changed to cope up with actual site conditions while drilling.*

5.4.5 Total Cable resistance

Total cable resistance includes the effective resistance of all single cables in parallel or series with the CP circuit.

Single Cable Resistance = Cable length x Unit Cable resistance

Unit resistances of commonly used CP cable are below.

Table 25: Cable resistance

Cable Size	Resistance in ohm per Meter
10 mm ²	0.002654
16 mm ²	0.001673
25 mm ²	0.001053
35 mm ²	0.000659
50 mm ²	0.000417
70 mm ²	0.000331
95 mm ²	0.000261
120 mm ²	0.000205
185 mm ²	0.000125

The cables resistance will be calculated as follows:

$$R_c = R_{ctT} + R_{cbpT} + R_{cpT} + R_{cdT} + R_{cbnT} + R_{cnT}$$

Where,

R_c = Total Cable resistance (Ohm)

R_{ctT} = Parallel resistance of all anode tail cables (Ohm)

R_{cbpT} = Parallel Positive branch cable resistance (Ohm)

R_{cpT} = Resistance of positive cable (Ohm)

R_{cdT} = Parallel drain cables resistance (Ohm)

R_{cbnT} = Parallel negative branch cable resistance (Ohm)

R_{cnT} = resistance of negative cable (Ohm)

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Table 26:Cable resistance							
Cable From	Cable To	New/E xisting	Cable ID	Details			
				size	L: Cable Length (m)	r: Cable resistan ce per meter (Ω/m)	Cable Resistan ce (Ω)
Anode 1	20 AJB	New	A1	10mm ²	49	0.002654	0.1300
Anode 2		New	A2	10mm ²	53	0.002654	0.1407
Anode 3		New	A3	10mm ²	57	0.002654	0.1513
Anode 4		New	A4	10mm ²	61	0.002654	0.1619
Anode 5		New	A5	10mm ²	65	0.002654	0.1725
Anode 6		New	A6	10mm ²	69	0.002654	0.1831
Anode 7		New	A7	10mm ²	73	0.002654	0.1937
Anode 8		New	A8	10mm ²	77	0.002654	0.2044
Anode 9		New	A9	10mm ²	81	0.002654	0.2150
Anode 10		New	A10	10mm ²	85	0.002654	0.2256
Anode 11		New	A11	10mm ²	89	0.002654	0.2362
Anode 12		New	A12	10mm ²	93	0.002654	0.2468
Anode 13		New	A13	10mm ²	97	0.002654	0.2574
Anode 14		New	A14	10mm ²	101	0.002654	0.2681
Anode 15		New	A15	10mm ²	105	0.002654	0.2787
Anode 16		New	A16	10mm ²	109	0.002654	0.2893
Anode 17		New	A17	10mm ²	113	0.002654	0.2999
Anode 18		New	A18	10mm ²	117	0.002654	0.3105
Anode tail cable parallel resistance,RctT1=							0.0114
No. of deep well							2
Total Anode tail cable parallel resistance,RctT=							0.0057
3T MPJB	20T AJB -1	New	(Rcbp1)	35mm ²	45	0.000659	0.0297
3T MPJB	20 T AJB -2	New	(Rcbp2)	35mm ²	45	0.000659	0.0297
Positive branch cable parallel resistance,RcbpT=							0.0148
TR	3T MPJB	New	(RcpT)	50mm ²	150	0.000417	0.0626
Pipeline (P1)	NJB-1	New	(Rcd1)	25mm ²	55	0.001053	0.0579

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<table><tr><td>Pipeline (P2)</td><td rowspan="3">NJB-2</td><td>New</td><td>(Rcd2)</td><td>25mm²</td><td>15</td><td>0.001053</td><td>0.0158</td></tr><tr><td>Pipeline (P1)</td><td>New</td><td>(Rcd1)</td><td>25mm²</td><td>55</td><td>0.001053</td><td>0.0579</td></tr><tr><td>Pipeline (P2)</td><td>New</td><td>(Rcd2)</td><td>25mm²</td><td>15</td><td>0.001053</td><td>0.0158</td></tr><tr><td colspan="7">Negative drain cable parallel resistance,RcdT=</td><td>0.0062</td></tr><tr><td>NJB-1</td><td>3T MNJB</td><td>New</td><td>(Rcbn1)</td><td>35mm²</td><td>300</td><td>0.000659</td><td>0.1977</td></tr><tr><td>NJB-2</td><td>3T MNJB</td><td>New</td><td>(Rcbn2)</td><td>35mm²</td><td>400</td><td>0.000659</td><td>0.2636</td></tr><tr><td colspan="7">Negative branch cable parallel resistance, from NJB to MNJB RcbnT=</td><td>0.1130</td></tr><tr><td>TR</td><td>pipeline</td><td>New</td><td>(RcnT)</td><td>50mm²</td><td>30</td><td>0.000417</td><td>0.0125</td></tr><tr><td colspan="7">RcT: Total Cable resistance(RctT + RcbpT +RcpT+ RcdT+ RcbnT+RcnT)=</td><td>0.2148</td></tr></table>									Pipeline (P2)	NJB-2	New	(Rcd2)	25mm²	15	0.001053	0.0158	Pipeline (P1)	New	(Rcd1)	25mm²	55	0.001053	0.0579	Pipeline (P2)	New	(Rcd2)	25mm²	15	0.001053	0.0158	Negative drain cable parallel resistance,RcdT=							0.0062	NJB-1	3T MNJB	New	(Rcbn1)	35mm²	300	0.000659	0.1977	NJB-2	3T MNJB	New	(Rcbn2)	35mm²	400	0.000659	0.2636	Negative branch cable parallel resistance, from NJB to MNJB RcbnT=							0.1130	TR	pipeline	New	(RcnT)	50mm²	30	0.000417	0.0125	RcT: Total Cable resistance(RctT + RcbpT +RcpT+ RcdT+ RcbnT+RcnT)=							0.2148
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RG	Anode resistance					3.8868	ohms																																																																							
Rc	Cable resistance					0.2148	ohms																																																																							
RT	Total circuit resistance(RG + Rc)					4.1016	ohms																																																																							
5.4.7 TR voltage required																																																																														
Table 28:Minimum TR voltage required																																																																														
RT	Total circuit resistance					4.1016	ohms																																																																							
I	Design current (Including Spare)					16.66	A																																																																							
emf	Back emf					2	V																																																																							
V	TR Min voltage Required =(RTx I)+2 =					70.34	V																																																																							
E	TR rated voltage Chosen					100	V																																																																							
5.4.8 TR AC power requirement																																																																														
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Ir	TR DC rated current					50	A																																																																							
E	TR DC rated Voltage					100	V																																																																							
Eac	AC input voltage					230	V																																																																							
	AC input phase					1	-																																																																							
Eff	Efficiency					80	%																																																																							
Pf	Power factor					0.8																																																																								
VA	AC input VA=(E x Ir)/(Eff x pf)					7812.5	VA																																																																							
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<table><tr><td>lac</td><td>AC input current=VA/Eac</td><td>33.967</td><td>A</td></tr></table>								lac	AC input current=VA/Eac	33.967	A										
lac	AC input current=VA/Eac	33.967	A																		
<p>5.4.9 Design life for Proposed Anode Qty</p> <p>Single Anode Output = 1.6 A (For 25 Years) Total No's of Anodes Proposed for this ICCP stations = 36 Anodes Total Anodes output = 36 * 1.6 = 57.6A (For 25 Years) Total design current required including spare leakage (15%) = 16.66 A</p> <p>Hence, Anode lifetime when operating at total design current (16.66A) will be = (25 * 57.6/16.66 = 86.4 Years</p> <p>So the calculated anode lifetime exceeds 50 years and complies with E16 Section 9.2.1.</p> <p><i>Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.</i></p>																					
<p>5.5 ICCP Station 4 @ KM 116+460(At HPT station)</p>																					
<p>5.5.1 ICCP Station-4 Description</p> <p>The area is rocky and the resistivity changing with depth(see section 8). Remote deep vertical anode bed is proposed at this location.In order to reduce anode resistance , 18 no's of MMO tubular anodes in two deep anode bed configuration is proposed. Anodes will be installed at 30 to 104m depth and minimum 100m away from pipelines. Each Anode tail cable will be terminated in a common 20 terminal junction box. Anode tail cable sizes will be 1C x 10mm2,HMWPE.The anode bed will be powered by a 100V/50A rectifier.A 1Cx 25 mm2 HMWPE negative cable will be installed for two pipeline and it will be terminated in 3T NJB. A 1Cx50mm2 cable will be installed between NJB and TR negative terminal. A 1Cx35mm2 HMWPE positive branch cable will be installed between 20T JB and 3T multi-purpose positive Junction box.Then 1Cx50mm2 HMWPE Main positive cable will be installed between 3T MPJB and Positive terminal of the TR. The Negative cable will be connected to pipeline using pin brazing.TR will be provided with remote monitoring unit. The two permanent copper -copper sulphate reference electrode and will be installed at drain point to monitor structure potential. A monitoring cable(2Cx2.5mm2) will be connected to pipeline one end using pin brazing. The other end of monitoring cable and RE cable(1Cx6mm2) will be terminated in RMU.</p>																					
<p>5.5.2 ICCP Current Requirement</p>																					
<table><tr><th colspan="7">Table 30:Current Requirement</th></tr><tr><th>Pipeline Name</th><th>No. of P/L's</th><th>Dia (M)</th><th>Coverage Length (M)</th><th>Area for two pipeline (M²)</th><th>Current Density (mA/m²)</th><th>Current Required (A)</th></tr></table>								Table 30:Current Requirement							Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M²)	Current Density (mA/m²)	Current Required (A)
Table 30:Current Requirement																					
Pipeline Name	No. of P/L's	Dia (M)	Coverage Length (M)	Area for two pipeline (M²)	Current Density (mA/m²)	Current Required (A)															
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PS3 to HPT	2	2.2352	63110	886327.93	0.015	13.295
HPT/C to HPT/A+B	1	1.524	622	2978.00	0.015	0.045
	1	2.032	4363	27852.15	0.015	0.418
Current Required for new pipelines (A)						13.757
Spare for leakage (15%)						2.064
Total design Current Required including leakage_T(A)						15.82
3 Times design current as per E16						47.46
TR Current rated Proposed (A)						50
TR voltage rating Proposed (V)						100

5.5.3 Quantity of Anodes Required

Table 31: Anode Quantity Required			
	Anode Type	MMO Tubular	
	Anode Length	100	cm
	Anode diameter	1.9	cm
I _a	Single anode current(for 25 years)	1.6	A
I _T	Design Current	15.82	A
N	Number of anode = I _T /I _a	10	Each
	Number of anode chosen (to lower anode resistance)	36	Each

Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.

5.5.4 Total Ground bed resistance

Table 32: Anodebed Resistance		
$R_G = \left[\frac{\rho}{2\pi \times L_c \times N} \right] \left[\ln \left(\frac{8xL_c}{D_c} \right) - 1 + \frac{2x}{5} \ln(0.656 \times N) \right]$		
	Anode configuration	Deep-Remote vertical
	Installation start depth from grade level (CM)	3000
	Anode length (CM)	100
N	Total Number of Anode Holes	2

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S	Anode Hole Spacing	6000
	Coke coverage above anode (CM)	300
	Coke coverage below anode (CM)	150
	Anode end to end spacing (CM)	300
p	soil resistivity (ohm-cm)	40749
La	Anode bed active column length (CM)	7350
Da	Anode bed active column Diameter (CM)	25.4
	Number of anode per hole (Each)	18
RG	Total Anode bed resistance (ohms)	3.2730

***Final anode configuration and depth may be changed to cope up with actual site conditions while drilling.*

5.5.5 Total Cable resistance

Total cable resistance includes the effective resistance of all single cables in parallel or series with the CP circuit.

Single Cable Resistance = Cable length x Unit Cable resistance

Unit resistances of commonly used CP cable are below.

Table 33:Cable resistance

Cable Size	Resistance in ohm per Meter
10 mm ²	0.002654
16 mm ²	0.001673
25 mm ²	0.001053
35 mm ²	0.000659
50 mm ²	0.000417
70 mm ²	0.000331
95 mm ²	0.000261
120 mm ²	0.000205
185 mm ²	0.000125

The cables resistance will be calculated as follows:

$$R_c = R_{ct} + R_{cbp} + R_{cp} + R_{cd} + R_{cn}$$

Where,

R_c = Total Cable resistance (Ohm)

R_{ct} = Parallel resistance of all anode tail cables (Ohm)

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RcbpT = Parallel Positive branch cable resistance (Ohm)
RcpT = Resistance of positive cable (Ohm)
RcdT = Parallel drain cables resistance (Ohm)
RcnT = resistance of negative cable (Ohm)

Table 10:Cable resistance							
Cable From	Cable To	New/Existing	Cable ID	Details			
				size	L: Cable Length (m)	r: Cable resistance per meter (Ω/m)	Cable Resistance (Ω)
Anode 1	20 AJB	New	A1	10mm ²	49	0.002654	0.1300
Anode 2		New	A2	10mm ²	53	0.002654	0.1407
Anode 3		New	A3	10mm ²	57	0.002654	0.1513
Anode 4		New	A4	10mm ²	61	0.002654	0.1619
Anode 5		New	A5	10mm ²	65	0.002654	0.1725
Anode 6		New	A6	10mm ²	69	0.002654	0.1831
Anode 7		New	A7	10mm ²	73	0.002654	0.1937
Anode 8		New	A8	10mm ²	77	0.002654	0.2044
Anode 9		New	A9	10mm ²	81	0.002654	0.2150
Anode 10		New	A10	10mm ²	85	0.002654	0.2256
Anode 11		New	A11	10mm ²	89	0.002654	0.2362
Anode 12		New	A12	10mm ²	93	0.002654	0.2468
Anode 13		New	A13	10mm ²	97	0.002654	0.2574
Anode 14		New	A14	10mm ²	101	0.002654	0.2681
Anode 15		New	A15	10mm ²	105	0.002654	0.2787
Anode 16		New	A16	10mm ²	109	0.002654	0.2893
Anode 17		New	A17	10mm ²	113	0.002654	0.2999
Anode 18		New	A18	10mm ²	117	0.002654	0.3105
Anode tail cable parallel resistance,RctT1=							0.0114
No. of deep well							2
Total Anode tail cable parallel resistance,RctT=							0.0057
3T MPJB	20T AJB - 1	New	(Rcbp1)	35mm ²	45	0.000659	0.0297

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<table><tr><td>3T MPJB</td><td>20T AJB - 2</td><td>New</td><td>(Rcbp2)</td><td>35mm²</td><td>45</td><td>0.000659</td><td>0.0297</td></tr><tr><td colspan="7">Positive branch cable parallel resistance,RcbpT=</td><td>0.0148</td></tr><tr><td>TR</td><td>3T MNJ B</td><td>New</td><td>(RcpT)</td><td>50mm²</td><td>200</td><td>0.000417</td><td>0.0834</td></tr><tr><td>Pipeline (P1)</td><td>NJB</td><td>New</td><td>(Rcd1)</td><td>25mm²</td><td>55</td><td>0.001053</td><td>0.0579</td></tr><tr><td>Pipeline (P2)</td><td>NJB</td><td>New</td><td>(Rcd2)</td><td>25mm²</td><td>15</td><td>0.001053</td><td>0.0158</td></tr><tr><td colspan="7">Negative drain cable parallel resistance,RcdT=</td><td>0.0124</td></tr><tr><td>TR</td><td>3T MPJ B</td><td>New</td><td>(RncT)</td><td>50mm²</td><td>200</td><td>0.000417</td><td>0.0834</td></tr><tr><td colspan="7">RcT: Total Cable resistance(RctT + RcbpT +RcpT+ RcdT+ RcnT)=</td><td>0.1998</td></tr></table>								3T MPJB	20T AJB - 2	New	(Rcbp2)	35mm²	45	0.000659	0.0297	Positive branch cable parallel resistance,RcbpT=							0.0148	TR	3T MNJ B	New	(RcpT)	50mm²	200	0.000417	0.0834	Pipeline (P1)	NJB	New	(Rcd1)	25mm²	55	0.001053	0.0579	Pipeline (P2)	NJB	New	(Rcd2)	25mm²	15	0.001053	0.0158	Negative drain cable parallel resistance,RcdT=							0.0124	TR	3T MPJ B	New	(RncT)	50mm²	200	0.000417	0.0834	RcT: Total Cable resistance(RctT + RcbpT +RcpT+ RcdT+ RcnT)=							0.1998
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5.5.6 Total Circuit Resistance																																																																							
Table 35:Total circuit resistance																																																																							
RG	Anode resistance					3.2703	ohms																																																																
Rc	Cable resistance					0.1998	ohms																																																																
RT	Total circuit resistance(RG + Rc)					3.4700	ohms																																																																
5.5.7 TR voltage Required																																																																							
Table 36:Minimum TR voltage required																																																																							
RT	Total circuit resistance					3.4700	ohms																																																																
I	Design current (Including Spare)					15.82	A																																																																
emf	Back emf					2	V																																																																
V	TR Min voltage Required =(RTx I)+2 =					56.90	V																																																																
E	TR rated voltage Chosen					100	V																																																																
5.5.8 TR AC power requirement																																																																							
Table 37:TR AC power requirement																																																																							
Ir	TR DC rated current					50	A																																																																
E	TR DC rated Voltage					100	V																																																																
Eac	AC input voltage					230	V																																																																
	AC input phase					1	-																																																																
Eff	Efficiency					80	%																																																																
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<table><tr><td>Pf</td><td>Power factor</td><td>0.8</td><td></td></tr><tr><td>VA</td><td>AC input VA=(E x Ir)/(Eff x pf)</td><td>7812.5</td><td>VA</td></tr><tr><td>Iac</td><td>AC input current=VA/Eac</td><td>33.967</td><td>A</td></tr></table>									Pf	Power factor	0.8		VA	AC input VA=(E x Ir)/(Eff x pf)	7812.5	VA	Iac	AC input current=VA/Eac	33.967	A
Pf	Power factor	0.8																		
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<p>5.5.9 Design life for Proposed Anode Qty</p> <p>Single Anode Output = 1.6 A (For 25 Years) Total No's of Anodes Proposed for this ICCP stations = 36 Anodes Total Anodes output = 36 * 1.6 = 57.6A (For 25 Years) Total design current required including spare leakage (15%) = 15.82 A</p> <p>Hence, Anode lifetime when operating at total design current (15.82A) will be = (25 * 57.6)/15.82 = 91 Years So the calculated anode lifetime exceeds 50 years and complies with E16 Section 9.2.1.</p> <p><i>Note:-Transformer have 3 times design current capacity. Additional TR capacity is considered for future requirements. If in case additional current required, additional anode to be added.</i></p> <p>5.6 ATTENUATION</p> <p>There are three main pipe sections(PS1 to PS2,PS2 to PS3 and PS3 to HPT) and two branch sections (HPT/C to HPT/A+B).The branch lines are short and hence excluded from attenuation calculation. ICCP stations are proposed at PS1, PS2, PS3 and HPT. All main line sections have same diameter, wall thickness and coating type. The PS1 to PS2 section is the longest one and the resistivity of this section varies widely. The first 12.5 km of this section has an average soil resistivity of 572 ohm-cm for 1.5 to 6m layer. The remaining portion (12.5 km to 169.729km) average soil resistivity is high (10500 ohm.cm). However, 2000 ohm-cm will be considered in calculations for this second portion conservatively.</p> <p>Separate attenuation calculation (considering soil resistivity variation) will be provided for 0-12.5km and 12.5 to 169.729km portions of PS1 to PS2 section.</p> <p>The drain point potential will be considered as 1.5V(0.9V change from native potential) and the farthest point protected potential will be 1V(0.4V change from native potential).</p> <p>Initially, the potential at km12.5 will be calculated considering drain point (km 0.00) protected potential as 1.5V. Attenuation from km12.5 to PS2 will be calculated based on maximum potential available at km 12.5 from initial calculations.</p> <p><u>Potential at km 12.5</u></p> <p>The following calculation will be utilized to determine the potential shift at km 12.5 from from one CP station at PS1.</p>																				
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<div>$E_d = E_{dp} /(\cosh(\alpha L))$</div> <p>Where:</p> <p>$E_{dp}$ = Maximum change in potential at drain point (1.5-0.6=0.9V) E_d = Potential change at a distance L(12.5km) from Drainpoint α = Attenuation factor L = Distance from drain point</p> <p>The following formulae are utilized for the above referenced calculation .</p> <p>$A = \pi * t (D-t)$</p> <p>Where :</p> <p>A = Cross sectional area of pipe in m2 0.12121 t = Pipe wall thickness in meter 17.4E-03 D = Diameter of pipe in meter 2.2352</p> <p>$R_s = (P_s * L) / A$</p> <p>Where :</p> <p>R_s = Pipe linear resistance in ohm / km 0.00149 P_s = Steel resistivity n ohm- meter 1.8E-07 L = Length of pipe in meter 1000 A = Cross sectional area of pipe 0.12121</p> <p>Specific Coating resistance (Rc) considered for 3LPE coating 40000 ohm m2 Corrected Specific Coating resistance, $R_P = (\text{soil resistivity} / 1000 \text{ ohm.cm}) * R_c$ Average Soil resistivity for PS1(km 0) to 12.5 km portion 572 ohm-cm Corrected Coating resistance, R_P in Ohm/m2 22880</p> <p>$R_L = R_P/ S_a$</p> <p>where :</p> <p>R_L = Coating Leakage resistance in ohm/km 3.26 R_P = Specefic Coating resistance in Ohm/m² 22880 S_a = Surface area of one kilometer of pipe in m2 7020.76</p> <div>$\alpha = \sqrt{\frac{RS}{RL}}$</div> <p>where : 0.021 α = Attenuation factor</p>								
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<div>RS = Pipe linear resistance0.00149</div> <div>RL = Coating leakage resistance3.26</div> <div>E_{dp} = (protected potential at Drain - E_{natural})</div> <div>Potential at drain point1.5</div> <div>Natural potential0.6</div> <div>E_{dp}0.90volts</div> <div>Potential shift at km 12.5 from from one CP station at PS1.</div> <div>E_d = E_{dp} /(cosh(αL)) = 0.87V</div> <div>Protected potential at Km12.5= (Ed + E natural)= 1.47V</div> <div><u>Attenuation from Km 12.5 to PS2</u></div> <div>The following calculation will be utilized to determine the protection coverage from km 12.5 to PS2 side from PS1 CP station.</div> <div>E_{dp} = E_d * cosh(αL)</div> <div>Where:</div> <div>E_{dp} = Maximum change in potential at km 12.5</div> <div>E_d = Potential change at a distance L from km 12.5</div> <div>α = Attenuation factor</div> <div>L = Distance from point km12.5(in km).</div> <div>The following formulae are utilized for the above referenced calculation .</div> <div>A = pi * t (D-t)</div> <div>Where :</div> <div>A = Cross sectional area of pipe in m20.12121</div> <div>t = Pipe wall thickness in meter17.4E-03</div> <div>D = Diameter of pipe in meter2.2352</div> <div>R_s = (P_s * L) / A</div> <div>Where :</div> <div>R_s = Pipe linear resistance in ohm / km0.00149</div> <div>P_s = Steel resistivity n ohm- meter1.8E-07</div> <div>L = Length of pipe in meter1000</div> <div>A = Cross sectional area of pipe0.12121</div> <div>Specific Coating resistance (Rc) considered for 3LPE40000 ohm m2</div>								
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<p>Corrected Specific Coating resistance, R_P = (soil resistivity / 1000 ohm.cm) * R_c</p> <p>Average Soil resistivity for 12.5 km to PS2 portion 2000 ohm-cm</p> <p>Corrected Coating resistance, R_P in Ohm/m2 80000</p> <p>$R_L = R_P / S_a$</p> <p>where :</p> <p>R_L = Coating Leakage resistance in ohm/km 11.39</p> <p>R_P = Specefic Coating resistance in Ohm/m2 80000</p> <p>S_a = Surface area of one kilometer of pipe in m2 7020.76</p> <div>$\alpha = \sqrt{\frac{RS}{RL}}$</div> <p>where :</p> <p>α = Attenuation factor 0.011</p> <p>RS = Pipe linear resistance 0.00149</p> <p>RL = Coating leakage resistance 11.39</p> <p>It is calculated a maximum potential of -1.47 volts at km 12.5.</p> <p>It is assumed a minimum potential of -1.0 volts at a distance L from km 12.5</p> <p>E_d (Potential change at a distance L in volts)</p> <p>E_d = (Protected Potential at L) - ($E_{natural}$)</p> <p>Potential at a distance L 1.00</p> <p>Natural potential 0.60</p> <p>E_d = 0.40 volts</p> <p>E_{dp} (Potential change at km 12.5 in volts)</p> <p>E_{dp} = (protected potential at km 12.5- $E_{natural}$)</p> <p>Potential at km 12.5 1.47</p> <p>Natural potential 0.6</p> <p>E_{dp} 0.87 volts</p> <p>Protected span,L is calculated at follows :</p> <p>$E_{dp} = E_d * \cosh (\alpha L)$</p>								
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<div data-bbox="387 344 766 510" data-label="Equation-Block"> $L = \frac{a \cosh \left(\frac{E_{dp}}{E_d} \right)}{\alpha}$ </div> <p>Therefore :</p> <p>L = 128.4 km</p> <p>Hence total coverage from PS1 CP station(towards PS2 side)= 12.5 + 128.4 =140.9km This is the worst case scenario in theoretical calculations. Based on above calculations, each CP system at operating within the assign parameters is capable of providing cathodic protection to maximum 128.4 kilometer section on each side of the pipeine. So the proposed CP stations can cover the whole length of pipelines as per above theoretical calculations.</p>									
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<div>6. INSTALLATION GUIDELINES</div>								
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<div><h3>6.1 General</h3><p>Cathodic protection system installation shall be conducted as per the separately submitted “Methods of Statement” documents for each kind of job. But the following are few general installation guidelines that need to be followed.</p><p>The cathodic protection systems will be carried out according to client standard and specifications, and the Project drawings and specifications.</p><p>Before commencing installation, these guidelines in conjunction with all relevant project drawings and documentation should be reviewed and understood. It should also be verified that any work permits required have been issued, and that it is acceptable to start the work.</p><h3>6.2 Safety</h3><p>The installation works will be carried out in a safe manner, with all site personnel, staff and labors, fully adopting client’s safety procedures.</p><p>All parties will be particularly aware of safety requirements, concerning working in trenches, hot work and installation of electrical equipments.</p><h3>6.3 Materials Handling</h3><p>All materials associated with the installation works will be considered as fragile, and will be treated accordingly.</p><p>All DC & AC cables will be handled and stored to avoid damage to the installation.</p><h3>6.4 Anode Installation</h3><p>Shallow vertical and deep anode bed installation shall be performed as per the attached design drawings and seperately submitted Method of Statement.</p><p>Anode shall be handled with a great care.</p><h3>6.5 Connection to Pipeline</h3><p>All cable connections to pipe will be provided by pin brazing.</p><p>Prior to coating, each weld will be tested for strength by tapping with a 0.5 kg hammer. Failed welds will be reworked.</p><h3>6.6 Permanent Reference Electrode</h3><p>Cu-CuSO4/Ag-Agcl permanent reference electrode c/w 1C x 6mm² HMWPE cable shall be installed in a horizontal way at the middle level of the pipeline at a distance of 20 CM.</p><p>RE will also be installed at PTS -17, PTS -34, PTS -51 (B1 package) & PTS-7(B2 package), PTS-54(B2 package).</p></div>								
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<p>6.7 Coupon</p> <p>Coupon with HMWPE twin cable (2 x 2.5 mm²) shall be installed in a horizontal way at the middle level of the pipeline at a distance of 10 CM.</p> <p>6.8 Junction Box</p> <p>Junction Box shall be installed at the location indicated in the project drawing and in accordance with client standard.</p> <p>The exact locations will be verified on site as being suitable for the installation.</p> <p>Be careful at the time of anode junction box installations. It is highly recommended to install the anodes first and then select the anode junction box location where all associated anode cable tails can reach. Therefore select the anode junction box location very carefully to avoid any problem related to short anode cable length.</p> <p>6.9 Current Test Station</p> <p>Current Test stations will be installed at a location proposed in the project drawings to accommodate the two 2 x 2.5mm² HMWPE measuring cable will be terminated in test stations at one end and pin brazed to pipeline at other end.</p> <p>The exact locations will be verified on site as being suitable for the installation.</p> <p>6.10 CABLE LAYING</p> <p>All cathodic protection cables going from/to for junction boxes, test station & transformer rectifiers will be buried under ground at a depth of 80cms as per attached project drawings & all buried cables shall be covered by warning tape.</p> <p>Special care will be taken to avoid damage to cable insulation during all stages of backfilling & Cable marker to be installed as per project drawings.</p> <p>6.11 Quality Control</p> <p>The installation works will, at all times, be carried out within an appropriate quality control system; this should be affected by strictly adhering to all materials approval requirements.</p>								
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ILF			Al-Rashid Trading & Contracting Co.			SOGEC		

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<div>7. BILL OF MATERIALS</div>								
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7.1 BILLS OF MATERIAL

Table 38: Permanent CP System Bill of Material – ICCP station 1 @ PS1

Bill of Material for ICCP Station-1 at PS1			
ITEM	DESCRIPTION	Unit	QTY
1	Conventional Transformer Rectifier with the following characteristics:		
	Transformer Rectifier, conventional, link bars, Single Phase 230 'V, 60 Hz AC input; '30"V/100A DC output, Oil immersed air cooled C/W NEMA 4X Hot dip galvanized Enclosure & Sunshade. The TRU will be equipped with the following meters:		
	1- Voltmeter (Analog)	Ea.	1
	2- Ammeter (Analog)		
	3- Potential meter (digital)		
	4- AC Voltmeter (Digital)		
	1. Voltage free dry contact for AC power failure alarm and leakage current switch shall be provided in the TR.		
	2. Provision for mounting Remote monitoring unit to be provided.		
	3. TRU Shall be in accordance to E16 specifications		
	RMU Monitoring unit Dart® for single Rectifier, DPM-TR-RS 485-GPS, Modbus, RS-485 c/w GPS receiver and mercury Relay, Input Voltage: 235 VAC	Ea	1
	Transformer Oil	Drum	3
	50 mm2 Grounding Cable (5m)	Each	1
	1.5" PVC coated conduit with end bushing and 60CM (length)	Each	4
	Duct Seal (5lb. per Pack)	Pack	1
2	Permanent Reference Electrodes: Ag/Agcl (Borin-STELTH 2 SRE-008-SUB) reference electrode c/w1C x 6mm2 HMWPE cable of 80m length	Ea	2
	Measuring cables for RMU: 2x2.5 MM2 HMWPE.	m	160
3	A1- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 49m	Ea.	1
	A2- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 53m	Ea.	1
	A3- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 57m	Ea.	1
	A4- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2	Ea.	1

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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		HMWPE cable tail of length: 61m							
		A5- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 65m						Ea.	1
		A6- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 69m						Ea.	1
		A7- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 73m						Ea.	1
		A8- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 77m						Ea.	1
		A9- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 81m						Ea.	1
		A10- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 85m						Ea.	1
	4	Anode Junction Box: 12-Terminal NEMA 4X Aluminum powder coated with shunt c/w 2" PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.						Ea.	1
	5	Negative Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt, Provision for Variable resistors 3ohm 100watts c/w 2" PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.						Ea.	1
	6	Lockable Current test station: 8 terminals with shunt (0.01 Ohm) lockable Big Fink test station, with a supplier dent lock, c/w 3" hot dip galvanized steel pipe 1.32 m length (SCH-20) Total of 1.7 M length (to the head), 3" PVC Elbow 900 with 150 mm 3" PVC Pipe (SCH-40) and stainless steel marker plate . Concrete foundation to be done by contractor on site						Each	1
	7	Measuring cables For CTS: 2x2.5 MM2 HMWPE.						Mtr.	200
	8	1CX50 mm² HMWPE Cable						Mtr.	450
	9	1 x 25 mm² HMWPE Cable						Mtr.	100
	10	Backfill: Calcined petroleum coke (50 lbs/bag)						Ea	140
	11	Casing PVC Pipe (12)" SCH-40 (315X9.2MM) with two bolts and one slot with 225MMX100MM as shown in drawing						Ea	1
	12	1inch elbow PVC SCH-40 (Vent pipe Elbow)						Ea	2
	13	MMO Anode centralizers (for 1220MMX25MM Anodes)						Ea	10
	14	1inch PVC pipe SCH-40 with perforated length 3m						Ea	14
	15	1inch PVC pipe SCH-40 with length 3m non perforated						Ea	11
	16	1inch PVC end cap SCH-40						Ea	1
	17	1inch PVC coupling (for interconnecting 1inch pipe on both sides)						Ea	25
	18	PVC Cement						Litre	3
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ILF			Al-Rashid Trading & Contracting Co.			SOGEC			

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	19	Cable marker: Red wood timber 100x100x1350 c/w identification marker and directional marker. Double arrow. Foundation (20x20x20CM; LxWXD).					Ea	4
		Concrete foundation to be done by contractor on site.						
	20	Cable lugs for 1CX50mm2 cable/8mm eye size					Each	5
	21	Cable lugs for 25mm2 cable/8mm eye size					Each	5
	22	Cable lugs for 2X2.5mm2 cable/8mm eye size					Each	10
	23	Pin Brazing Charges – 8mm					Charge	10
	24	Ceramic Ferrules – 8mm					Ferrule	10
	25	Coating repair: Melt Stick Epoxy					Stick	10
	26	Warning tape: written “Attention Cable”, 6”x 200M Roll					Roll	2
	27	Cable Tie, Nylon 200 X3.5mm packet					Pack	1
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Table 39: Permanent CP System Bill of Material – ICCP station 2 @PS2

Bill of Material for ICCP Station-2 at PS2			
ITEM	DESCRIPTION	Unit	QTY
1	Conventional Transformer Rectifier with the following characteristics:		
	Transformer Rectifier, conventional, link bars, Single Phase 230 'V, 60 Hz AC input; '100'V/100A DC output, Oil immersed air cooled C/W NEMA 4X Hot dip galvanized Enclosure & Sunshade. The TRU will be equipped with the following meters:		
	1- Voltmeter (Analog)	Ea.	1
	2- Ammeter (Analog)		
	3- Potential meter (digital)		
	4- AC Voltmeter (Digital)		
	1. Voltage free dry contact for AC power failure alarm and leakage current switch shall be provided in the TR		
	2. Provision for mounting Remote monitoring unit to be provided.		
	3. TRU Shall be in accordance to E16 specifications		
	RMU Monitoring unit Dart® for single Rectifier, DPM-TR-RS 485-GPS,Modbus, RS-485 c/w GPS receiver and mercury Relay, Input Voltage: 235 VAC	Ea	1
	Transformer Oil	Drum	3
	50 mm2 Grounding Cable (5m)	Each	1
	1.5" PVC coated conduit with end bushing and 60CM (length)	Each	4
	Duct Seal (5lb. per Pack)	Pack	1
2	Permanent Reference Electrodes: Copper/Copper Sulphate reference electrode(Borin Stealth-2, SRE-007-CUY) c/w1C x 6mm2 HMWPE cable of 500m length	Ea	1
	Permanent Reference Electrodes: Copper/Copper Sulphate reference electrode(Borin Stealth-2, SRE-007-CUY) c/w1C x 6mm2 HMWPE cable of 150 m length	Ea	1
	Measuring cables for RMU: 2x2.5 MM2 HMWPE.	m	650
3	A1- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 49m	Ea.	2
	A2- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 53m	Ea.	2
	A3- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2	Ea.	2

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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		HMWPE cable tail of length: 57m						
		A4- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 61m					Ea.	2
		A5- Mixed Metal Oxide MMO (122Cm x 3.18 Cm), complete with 16 MM2 HMWPE cable tail of length: 65m					Ea.	2
	4	Anode Junction Box: 6-Terminal NEMA 4X Aluminum powder coated with shunt c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.					Ea.	2
	5	Multi -purpose positive Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate.					Ea.	1
	6	Negative Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.					Ea.	2
	7	Multi-purpose negative Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate.					Ea.	1
	8	Lockable Current test station: 8 terminals with shunt (0.01 Ohm) lockable Big Fink test station, with a supplier dent lock, c/w 3” hot dip galvanized steel pipe 1.32 m length (SCH-20) Total of 1.7 M length (to the head), 3” PVC Elbow 900 with 150 mm 3” PVC Pipe (SCH-40) and stainless steel marker plate . Concrete foundation to be done by contractor on site.					Each	1
	9	Measuring cables For CTS: 2x2.5 MM2 HMWPE.					Mtr.	200
	10	1CX50 mm² HMWPE Cable					Mtr.	850
	11	1 x 25 mm² HMWPE Cable					Mtr.	200
	12	1 x 35 mm² HMWPE Cable					Mtr.	250
	13	Backfill: Calcined petroleum coke (50 lbs/bag)					Ea	140
	14	Casing PVC Pipe (12)" SCH-40 (315X9.2MM) with two bolts and one slot with 225MMX100MM as shown in drawing					Ea	2
	15	1inch elbow PVC SCH-40 (Vent pipe Elbow)					Ea	4
	16	MMO Anode centralizers (for 1220MMX25MM Anodes)					Ea	10
	17	1inch PVC pipe SCH-40 with perforated length 3m					Ea	14
	18	1inch PVC pipe SCH-40 with length 3m non perforated					Ea	22
	19	1inch PVC end cap SCH-40					Ea	2
	20	1inch PVC coupling (for interconnecting 1inch pipe on both sides)					Ea	36
	21	PVC Cement					Litre	6
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ILF			Al-Rashid Trading & Contracting Co.			SOGEC		

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<table><tr><td>22</td><td>Cable marker: Red wood timber 100x100x1350 c/w identification marker and directional marker. Double arrow. Foundation (20x20x20CM; LxWxD).</td><td>Ea</td><td>5</td></tr><tr><td></td><td>Concrete foundation to be done by contractor on site.</td><td></td><td></td></tr><tr><td>23</td><td>Cable lugs for 1CX50mm2 cable/8mm eye size</td><td>Each</td><td>5</td></tr><tr><td>24</td><td>Cable lugs for 25mm2 cable/8mm eye size</td><td>Each</td><td>10</td></tr><tr><td>25</td><td>Cable lugs for 2X2.5mm2 cable/8mm eye size</td><td>Each</td><td>5</td></tr><tr><td>26</td><td>Pin Brazing Charges – 8mm</td><td>Charge</td><td>15</td></tr><tr><td>27</td><td>Ceramic Ferrules – 8mm</td><td>Ferrule</td><td>15</td></tr><tr><td>28</td><td>Coating repair: Melt Stick Epoxy</td><td>Stick</td><td>15</td></tr><tr><td>29</td><td>Warning tape: written “Attention Cable”, 6”x 200M Roll</td><td>Roll</td><td>2</td></tr><tr><td>30</td><td>Cable Tie, Nylon 200 X3.5mm packet</td><td>Pack</td><td>1</td></tr></table>									22	Cable marker: Red wood timber 100x100x1350 c/w identification marker and directional marker. Double arrow. Foundation (20x20x20CM; LxWxD).	Ea	5		Concrete foundation to be done by contractor on site.			23	Cable lugs for 1CX50mm2 cable/8mm eye size	Each	5	24	Cable lugs for 25mm2 cable/8mm eye size	Each	10	25	Cable lugs for 2X2.5mm2 cable/8mm eye size	Each	5	26	Pin Brazing Charges – 8mm	Charge	15	27	Ceramic Ferrules – 8mm	Ferrule	15	28	Coating repair: Melt Stick Epoxy	Stick	15	29	Warning tape: written “Attention Cable”, 6”x 200M Roll	Roll	2	30	Cable Tie, Nylon 200 X3.5mm packet	Pack	1
22	Cable marker: Red wood timber 100x100x1350 c/w identification marker and directional marker. Double arrow. Foundation (20x20x20CM; LxWxD).	Ea	5																																													
	Concrete foundation to be done by contractor on site.																																															
23	Cable lugs for 1CX50mm2 cable/8mm eye size	Each	5																																													
24	Cable lugs for 25mm2 cable/8mm eye size	Each	10																																													
25	Cable lugs for 2X2.5mm2 cable/8mm eye size	Each	5																																													
26	Pin Brazing Charges – 8mm	Charge	15																																													
27	Ceramic Ferrules – 8mm	Ferrule	15																																													
28	Coating repair: Melt Stick Epoxy	Stick	15																																													
29	Warning tape: written “Attention Cable”, 6”x 200M Roll	Roll	2																																													
30	Cable Tie, Nylon 200 X3.5mm packet	Pack	1																																													
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Table 40: Permanent CP System Bill of Material – ICCP station 3 @PS3

Bill of Material for ICCP Station-3 at PS3			
ITEM	DESCRIPTION	Unit	QTY
1	Conventional Transformer Rectifier with the following characteristics:		
	Transformer Rectifier, conventional, link bars, Single Phase 230 'V, 60 Hz AC input; '100V/50A DC output, Oil immersed air cooled C/W NEMA 4X Hot dip galvanized Enclosure & Sunshade. The TRU will be equipped with the following meters:		
	1- Voltmeter (Analog)	Ea.	1
	2- Ammeter (Analog)		
	3- Potential meter (digital)		
	4- AC Voltmeter (Digital)		
	1. Voltage free dry contact for AC power failure alarm and leakage current switch shall be provided in the TR		
	2. Provision for mounting Remote monitoring unit to be provided.		
	3. TRU Shall be in accordance to E16 specifications		
	RMU Monitoring unit Dart® for single Rectifier, DPM-TR-RS 485-GPS,Modbus, RS-485 c/w GPS receiver and mercury Relay, Input Voltage: 235 VAC	Ea	1
	Transformer Oil	Drum	2
	50 mm2 Grounding Cable (5m)	Each	1
	1.5" PVC coated conduit with end bushing and 60CM (length)	Each	4
	Duct Seal (5lb. per Pack)	Pack	1
2	Permanent Reference Electrodes: Copper/Copper Sulphate reference electrode(Borin Stealth-2, SRE-007-CUY) c/w1C x 6mm2 HMWPE cable of 300m length	Ea	2
	Measuring cables for RMU: 2x2.5 MM2 HMWPE.	m	600
3	A1- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 49m	Ea.	2
	A2- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 53m	Ea.	2
	A3- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 57m	Ea.	2
	A4- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 61m	Ea.	2

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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		A5- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 65m						Ea.	2
		A6- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 69m						Ea.	2
		A7- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 73m						Ea.	2
		A8- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 77m						Ea.	2
		A9- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 81m						Ea.	2
		A10- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 85m						Ea.	2
		A11- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 89m						Ea.	2
		A12- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 93m						Ea.	2
		A13- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 97m						Ea.	2
		A14- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 101m						Ea.	2
		A15- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 105m						Ea.	2
		A16- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 16 MM2 HMWPE cable tail of length: 109m						Ea.	2
		A17- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 16 MM2 HMWPE cable tail of length: 113m						Ea.	2
		A18- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 16 MM2 HMWPE cable tail of length: 117m						Ea.	2
	4	Anode Junction Box: 20-Terminal NEMA 4X Aluminum powder coated with shunt c/w 2" PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.						Ea.	2
	5	Multi -purpose positive Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2" PVC Coated conduit and hot dip galvanized Support Channel & name plate.						Ea.	1
	6	Negative Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2" PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.						Ea.	2
	7	Multi-purpose negative Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2" PVC Coated conduit and hot dip galvanized Support Channel & name plate.						Ea.	1
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<table><tr><th>ITEM</th><th>DESCRIPTION</th><th>Unit</th><th>QTY</th></tr><tr><td rowspan="10">1</td><td>Conventional Transformer Rectifier with the following characteristics:</td><td></td><td></td></tr><tr><td>Transformer Rectifier, conventional, link bars, Single Phase 230 'V, 60 Hz AC input; '100'V/50A DC output, Oil immersed air cooled C/W NEMA 4X Hot dip galvanized Enclosure & Sunshade. The TRU will be equipped with the following meters:</td><td></td><td></td></tr><tr><td>1- Voltmeter (Analog)</td><td>Ea.</td><td>1</td></tr><tr><td>2- Ammeter (Analog)</td><td></td><td></td></tr><tr><td>3- Potential meter (digital)</td><td></td><td></td></tr><tr><td>4- AC Voltmeter (Digital)</td><td></td><td></td></tr><tr><td>1. Voltage free dry contact for AC power failure alarm and leakage current switch shall be provided in the TR</td><td></td><td></td></tr><tr><td>2. Provision for mounting Remote monitoring unit to be provided.</td><td></td><td></td></tr><tr><td>3. TRU Shall be in accordance to E16 specifications</td><td></td><td></td></tr><tr><td>RMU Monitoring unit Dart® for single Rectifier, DPM-TR-RS 485-GPS,Modbus, RS-485 c/w GPS receiver and mercury Relay, Input Voltage: 235 VAC</td><td>Ea</td><td>1</td></tr><tr><td>Transformer Oil</td><td>Drum</td><td>2</td></tr><tr><td>50 mm2 Grounding Cable (5m)</td><td>Each</td><td>1</td></tr><tr><td>1.5” PVC coated conduit with end bushing and 60CM (length)</td><td>Each</td><td>4</td></tr><tr><td>Duct Seal (5lb. per Pack)</td><td>Pack</td><td>1</td></tr><tr><td rowspan="2">2</td><td>Permanent Reference Electrodes: Copper/Copper Sulphate reference electrode(Borin Stealth-2, SRE-007-CUY) c/w1C x 6mm2 HMWPE cable of 120m length</td><td>Ea</td><td>2</td></tr><tr><td>Measuring cables for RMU: 2x2.5 MM2 HMWPE.</td><td>m</td><td>250</td></tr><tr><td rowspan="6">3</td><td>A1- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 49m</td><td>Ea.</td><td>2</td></tr><tr><td>A2- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 53m</td><td>Ea.</td><td>2</td></tr><tr><td>A3- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 57m</td><td>Ea.</td><td>2</td></tr><tr><td>A4- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 61m</td><td>Ea.</td><td>2</td></tr><tr><td>A5- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 65m</td><td>Ea.</td><td>2</td></tr><tr><td>A6- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2</td><td>Ea.</td><td>2</td></tr></table>									ITEM	DESCRIPTION	Unit	QTY	1	Conventional Transformer Rectifier with the following characteristics:			Transformer Rectifier, conventional, link bars, Single Phase 230 'V, 60 Hz AC input; '100'V/50A DC output, Oil immersed air cooled C/W NEMA 4X Hot dip galvanized Enclosure & Sunshade. The TRU will be equipped with the following meters:			1- Voltmeter (Analog)	Ea.	1	2- Ammeter (Analog)			3- Potential meter (digital)			4- AC Voltmeter (Digital)			1. Voltage free dry contact for AC power failure alarm and leakage current switch shall be provided in the TR			2. Provision for mounting Remote monitoring unit to be provided.			3. TRU Shall be in accordance to E16 specifications			RMU Monitoring unit Dart® for single Rectifier, DPM-TR-RS 485-GPS,Modbus, RS-485 c/w GPS receiver and mercury Relay, Input Voltage: 235 VAC	Ea	1	Transformer Oil	Drum	2	50 mm2 Grounding Cable (5m)	Each	1	1.5” PVC coated conduit with end bushing and 60CM (length)	Each	4	Duct Seal (5lb. per Pack)	Pack	1	2	Permanent Reference Electrodes: Copper/Copper Sulphate reference electrode(Borin Stealth-2, SRE-007-CUY) c/w1C x 6mm2 HMWPE cable of 120m length	Ea	2	Measuring cables for RMU: 2x2.5 MM2 HMWPE.	m	250	3	A1- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 49m	Ea.	2	A2- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 53m	Ea.	2	A3- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 57m	Ea.	2	A4- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 61m	Ea.	2	A5- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 65m	Ea.	2	A6- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2	Ea.	2
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JUBAIL-RIYADH WATER TRANSMISSION SYSTEM									
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		HMWPE cable tail of length: 69m							
		A7- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 73m						Ea.	2
		A8- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 77m						Ea.	2
		A9- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 81m						Ea.	2
		A10- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 85m						Ea.	2
		A11- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 89m						Ea.	2
		A12- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 93m						Ea.	2
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		A15- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 10 MM2 HMWPE cable tail of length: 105m						Ea.	2
		A16- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 16 MM2 HMWPE cable tail of length: 109m						Ea.	2
		A17- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 16 MM2 HMWPE cable tail of length: 113m						Ea.	2
		A18- Mixed Metal Oxide MMO (100Cm x 1.9 Cm), complete with 16 MM2 HMWPE cable tail of length: 117m						Ea.	2
	4	Anode Junction Box: 20-Terminal NEMA 4X Aluminum powder coated with shunt c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.						Ea.	2
	5	Negative Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate. Concrete foundation to be done by contractor on site.						Ea.	1
	6	Multi -purpose positive Junction Box: 3-Terminal NEMA 4X Aluminum powder coated with shunt & space for Variable resistors 3ohm 100watts c/w 2” PVC Coated conduit and hot dip galvanized Support Channel & name plate.						Ea.	1
	7	Lockable Current test station: 8 terminals with shunt (0.01 Ohm) lockable Big Fink test station, with a supplier dent lock, c/w 3” hot dip galvanized steel pipe 1.32 m length (SCH-20) Total of 1.7 M length (to the head), 3” PVC Elbow 900 with 150 mm 3” PVC Pipe (SCH-40) and stainless steel marker plate . Concrete foundation to be done by contractor on site						Ea.	1
	8	Measuring cables For CTS: 2x2.5 MM2 HMWPE.						Mtr.	200
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<table><tr><td>9</td><td>1CX50 mm² HMWPE Cable</td><td>Mtr.</td><td>500</td></tr><tr><td>10</td><td>1 x 25 mm² HMWPE Cable</td><td>Mtr.</td><td>100</td></tr><tr><td>11</td><td>1 x 35 mm² HMWPE Cable</td><td>Mtr.</td><td>90</td></tr><tr><td>12</td><td>Backfill: Calcined petroleum coke (50 lbs/bag)</td><td>Ea</td><td>480</td></tr><tr><td>13</td><td>Casing PVC Pipe (12)" SCH-40 (315X9.2MM) with two bolts and one slot with 225MMX100MM as shown in drawing</td><td>Ea</td><td>2</td></tr><tr><td>14</td><td>1inch elbow PVC SCH-40 (Vent pipe Elbow)</td><td>Ea</td><td>4</td></tr><tr><td>15</td><td>MMO Anode centralizers (for 1220MMX25MM Anodes)</td><td>Ea</td><td>36</td></tr><tr><td>16</td><td>1inch PVC pipe SCH-40 with perforated length 3m</td><td>Ea</td><td>48</td></tr><tr><td>17</td><td>1inch PVC pipe SCH-40 with length 3m non perforated</td><td>Ea</td><td>22</td></tr><tr><td>18</td><td>1inch PVC end cap SCH-40</td><td>Ea</td><td>2</td></tr><tr><td>19</td><td>1inch PVC coupling (for interconnecting 1inch pipe on both sides)</td><td>Ea</td><td>70</td></tr><tr><td>20</td><td>PVC Cement</td><td>Litre</td><td>6</td></tr><tr><td>21</td><td>Cable marker: Red wood timber 100x100x1350 c/w identification marker and directional marker. Double arrow. Foundation (20x20x20CM; LxWXD). Concrete foundation to be done by contractor on site.</td><td>Ea</td><td>5</td></tr><tr><td>22</td><td>Cable lugs for 1CX50mm2 cable/8mm eye size</td><td>Each</td><td>4</td></tr><tr><td>23</td><td>Cable lugs for 25mm2 cable/8mm eye size</td><td>Each</td><td>6</td></tr><tr><td>24</td><td>Cable lugs for 2X2.5mm2 cable/8mm eye size</td><td>Each</td><td>5</td></tr><tr><td>25</td><td>Pin Brazing Charges – 8mm</td><td>Charge</td><td>11</td></tr><tr><td>26</td><td>Ceramic Ferrules – 8mm</td><td>Ferrule</td><td>11</td></tr><tr><td>27</td><td>Coating repair: Melt Stick Epoxy</td><td>Stick</td><td>11</td></tr><tr><td>28</td><td>Warning tape: written “Attention Cable”, 6”x 200M Roll</td><td>Roll</td><td>2</td></tr><tr><td>29</td><td>Cable Tie, Nylon 200 X3.5mm packet</td><td>Pack</td><td>1</td></tr></table>										9	1CX50 mm² HMWPE Cable	Mtr.	500	10	1 x 25 mm² HMWPE Cable	Mtr.	100	11	1 x 35 mm² HMWPE Cable	Mtr.	90	12	Backfill: Calcined petroleum coke (50 lbs/bag)	Ea	480	13	Casing PVC Pipe (12)" SCH-40 (315X9.2MM) with two bolts and one slot with 225MMX100MM as shown in drawing	Ea	2	14	1inch elbow PVC SCH-40 (Vent pipe Elbow)	Ea	4	15	MMO Anode centralizers (for 1220MMX25MM Anodes)	Ea	36	16	1inch PVC pipe SCH-40 with perforated length 3m	Ea	48	17	1inch PVC pipe SCH-40 with length 3m non perforated	Ea	22	18	1inch PVC end cap SCH-40	Ea	2	19	1inch PVC coupling (for interconnecting 1inch pipe on both sides)	Ea	70	20	PVC Cement	Litre	6	21	Cable marker: Red wood timber 100x100x1350 c/w identification marker and directional marker. Double arrow. Foundation (20x20x20CM; LxWXD). Concrete foundation to be done by contractor on site.	Ea	5	22	Cable lugs for 1CX50mm2 cable/8mm eye size	Each	4	23	Cable lugs for 25mm2 cable/8mm eye size	Each	6	24	Cable lugs for 2X2.5mm2 cable/8mm eye size	Each	5	25	Pin Brazing Charges – 8mm	Charge	11	26	Ceramic Ferrules – 8mm	Ferrule	11	27	Coating repair: Melt Stick Epoxy	Stick	11	28	Warning tape: written “Attention Cable”, 6”x 200M Roll	Roll	2	29	Cable Tie, Nylon 200 X3.5mm packet	Pack	1
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23	Cable lugs for 25mm2 cable/8mm eye size	Each	6																																																																																										
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Table 42: Common Bill of Materials for Coupon Test Station																																																																																													
ITEM		DESCRIPTION						Unit	QTY																																																																																				
1		Permanent Reference Electrodes: Copper/Copper Sulphate reference electrode(Borin Stealth-2, SRE-007-CUY) c/w1C x 6mm2 HMWPE cable with length 15m						Ea	5																																																																																				
2		Test coupon: 10cm2 sensing area & 2CX 2.5mm2 HMWPE cable with length 15m						Ea.	5																																																																																				
3		Cable lugs for 1cX6mm2 cable/8mm eye size						Each	5																																																																																				
4		Cable lugs for 2cX2.5mm2 cable/8mm eye size						Each	10																																																																																				
Final Engineering				Contractor				Subcontractor																																																																																					
ILF				Al-Rashid Trading & Contracting Co.				SOGEC																																																																																					

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JUBAIL-RIYADH WATER TRANSMISSION SYSTEM																
Subject:		Permanent Cathodic Protection System Design For B1 & B2 Packages Pipelines					70-YF00-J-301									
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		Date	01-03-2020	08-07-2020	28-11-20	04-08-22										
<table border="1"> <tr> <td>5</td> <td>SS bolts M8 with nuts and washers (for Test stations)</td> <td>Each</td> <td>25</td> </tr> <tr> <td>6</td> <td>Magnetic switch</td> <td>Each</td> <td>5</td> </tr> </table> <p>Note: Test station and Pipeline connection cables already provided & installed in Temporary CP Package</p>									5	SS bolts M8 with nuts and washers (for Test stations)	Each	25	6	Magnetic switch	Each	5
5	SS bolts M8 with nuts and washers (for Test stations)	Each	25													
6	Magnetic switch	Each	5													
Final Engineering			Contractor			Subcontractor										
ILF			Al-Rashid Trading & Contracting Co.			SOGEC										

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<div>8. SOIL RESISTIVITY DATA</div>								
Final Engineering			Contractor			Subcontractor		
ILF			Al-Rashid Trading & Contracting Co.			SOGEC		

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	SPECIALIZED OIL & GAS ENGINEERING COMPANY						Sheet No
	CATHODIC PROTECTION SYSTEM						1
	CLIENT: Al rashid Trading & Contracting Co.						
	END CLIENT: SWCC						
	STRUCTURE: WATER PIPELINE OF B1 & B2 PACKAGE						of 1
SOIL RESISTIVITY SURVEY REPORT							
Method:	WENNER 4-PIN	Manufacturer		Megger	Model		DET2/2
Serial No.	1015159958	Cal.date		9-Jul-19	Cal. Due date		8-Jul-20
Location	Jubail- Riyadh Water Transmission system			Weather:		Sunny	
Soil condition	Sandy			CP System:		ICCP	
Crew member	Tabrez						
Location	STA	Depth (Cm)	Resistance (Ω)	Barnes' Layer Resistance (Ω)		Layer Resistivity (Ω-Cm)	Average Resistivity (Ω-Cm)
1	PS1	1500	0.070	(0-1500)	0.070	660	377
		3000	0.02	(1500-3000)	0.028	264	
		6000	0.01	(3000-6000)	0.020	377	
		9000	0	(6000-9000)	0.000	0	
2	PS2	1500	6.360	(0-1500)	6.360	59942	5107
		3000	1.17	(1500-3000)	1.434	13513	
		6000	0.22	(3000-6000)	0.271	5107	
		9000	0.06	(6000-9000)	0.083	1555	
3	PS3	1500	6.270	(0-1500)	6.270	59093	48432
		3000	3.12	(1500-3000)	6.210	58531	
		6000	1.49	(3000-6000)	2.852	53759	
		9000	0.91	(6000-9000)	2.338	44066	
				(3000-9000)	1.285	48432	
4	HPT	1500	5.160	(0-1500)	5.160	48632	40749
		3000	2.56	(1500-3000)	5.081	47884	
		6000	1.23	(3000-6000)	2.368	44627	
		9000	0.76	(6000-9000)	1.989	37491	
				(3000-9000)	1.081	40749	
Remarks:							
Position:		Technician/supervisor		C.P.Engineer			
Company:		Sogec - CP		Sogec - CP			
Signature:							
Name:		Tabrez		Kalaiyaran			

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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<div>9. PS2-PS3 EXISTING PIPELINE (D& E) SUERVY</div>								
Final Engineering			Contractor			Subcontractor		
ILF			Al-Rashid Trading & Contracting Co.			SOGEC		

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9.1 EXISTING CP SYSTEM DETAILS

9.1.1 TRANSFORMER RECTIFIER & JB DETAILS (PS2)

Area Detail	PS2 (D&E)
Seriall No	231-12-0035
Rated Dc O/P	100V/50A
AC input	400V, 3ph
Class	OA
Operating Output	32 V / 27. A
Shunt Details	50A / 50mV
Date of Manufacture	2012
Current setting	FINE 7 COURSE B

Anode Juntion Box		
S.No	Anode numebr	Andoe current (A)
1	A-1	5.76
2	A-2	1.40
3	A-3	1.90
4	A-4	1.30
5	A-5	1.30
6	A-6	1.60
Total current		13.26

9.1.2 TRANSFORMER RECTIFIER & JB DETAILS (PS3)

Area Detail	PS3 –LINE D
Seriall No	258-13-00371
Rated Dc O/P	100V/50A
AC input	400V, 3ph
Class	OA
Operating Output	14.70 V / 9.55 A
Shunt Details	50A / 50mV
Date of Manufacture	2013
Current setting	FINE 3 COURSE C

Anode Juntion Box-1		
S.No	Anode numebr	Andoe current (A)
1	A-1	1.07
2	A-2	1.03
3	A-3	0.80
4	A-4	0.56
5	A-5	0.84
6	A-6	1.09
Total current		5.39

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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Anode Junction Box-2		
S.No	Anode numebr	Andoe current (A)
1	A-1	0.90
2	A-2	1.08
3	A-3	0.50
4	A-4	1.10
5	A-5	0.80
6	A-6	1.40
Total current		5.78

9.1.3 TRANSFORMER RECTIFIER & JB DETAILS (PS3)

Area Detail	PS3 –LINE E
Seriall No	258-13-00370
Rated Dc O/P	100V/50A
AC input	400V, 3ph
Class	OA
Operating Output	12.85 V / 7.90 A
Shunt Details	50A / 50mV
Date of Manufacture	2013
Current setting	FINE 3 COURSE C

Anode Junction Box-1		
S.No	Anode numebr	Andoe current (A)
1	A-1	0.96
2	A-2	0.88
3	A-3	1.06
4	A-4	1.00
5	A-5	0.94
6	A-6	0.44
Total current		5.24

Anode Junction Box-2		
S.No	Anode numebr	Andoe current (A)
1	A-1	0.48
2	A-2	0.92
3	A-3	0.55
4	A-4	1.09
5	A-5	0.90
6	A-6	1.40
Total current		5.40

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC

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	<table><tr><th colspan="3">SWCC PIPELINE -D</th><th colspan="3">SWCC PIPELINE -E</th></tr><tr><th>Chainage (Km)</th><th>ON (-mv)</th><th>Instant off (-mv)</th><th>Chainage (Km)</th><th>ON(-mv)</th><th>Instant off(-mv)</th></tr><tr><td>129+642</td><td>1356</td><td>908</td><td>129+708</td><td>1360</td><td>911</td></tr><tr><td>131+631</td><td>1293</td><td>873</td><td>133+677</td><td>1312</td><td>885</td></tr><tr><td>133+616</td><td>1275</td><td>870</td><td>135+696</td><td>1295</td><td>879</td></tr><tr><td>135+630</td><td>1287</td><td>865</td><td>137+693</td><td>1290</td><td>877</td></tr><tr><td>137+627</td><td>1260</td><td>866</td><td>139+694</td><td>1283</td><td>871</td></tr><tr><td>139+629</td><td>1266</td><td>873</td><td>141+709</td><td>1300</td><td>879</td></tr><tr><td>141+643</td><td>1293</td><td>870</td><td>143+222</td><td>1327</td><td>880</td></tr><tr><td>143+136</td><td>1290</td><td>865</td><td>144+017</td><td>1320</td><td>886</td></tr><tr><td>146+126</td><td>1302</td><td>877</td><td>146+487</td><td>1351</td><td>899</td></tr><tr><td>148+126</td><td>1309</td><td>889</td><td>148+489</td><td>1362</td><td>912</td></tr><tr><td>150+132</td><td>1354</td><td>916</td><td>150+143</td><td>1345</td><td>910</td></tr><tr><td>152+135</td><td>1350</td><td>899</td><td>152+416</td><td>1370</td><td>918</td></tr><tr><td>154+118</td><td>1318</td><td>892</td><td>154+401</td><td>1358</td><td>903</td></tr><tr><td>156+135</td><td>1347</td><td>910</td><td>156+418</td><td>1366</td><td>917</td></tr><tr><td>157+993</td><td>1340</td><td>905</td><td>158+276</td><td>1362</td><td>914</td></tr><tr><td>160+125</td><td>1330</td><td>922</td><td>160+448</td><td>1326</td><td>919</td></tr><tr><td>162+147</td><td>1464</td><td>963</td><td>162+419</td><td>1380</td><td>950</td></tr><tr><td>164+142</td><td>1516</td><td>946</td><td>164+424</td><td>1314</td><td>908</td></tr><tr><td>166+156</td><td>1463</td><td>940</td><td>166+438</td><td>1404</td><td>937</td></tr><tr><td>168+128</td><td>1350</td><td>911</td><td>168+400</td><td>1339</td><td>915</td></tr><tr><td>170+128</td><td>1307</td><td>906</td><td>170+409</td><td>1311</td><td>889</td></tr><tr><td>172+147</td><td>1291</td><td>874</td><td>172+443</td><td>1300</td><td>885</td></tr><tr><td>174+134</td><td>1298</td><td>870</td><td>174+416</td><td>1307</td><td>874</td></tr><tr><td>176+162</td><td>1292</td><td>867</td><td>176+407</td><td>1385</td><td>877</td></tr><tr><td>178+125</td><td>1286</td><td>866</td><td>178+407</td><td>1280</td><td>877</td></tr><tr><td>180+136</td><td>1310</td><td>917</td><td>180+147</td><td>1329</td><td>903</td></tr><tr><td>182+133</td><td>1341</td><td>914</td><td>182+415</td><td>1337</td><td>920</td></tr><tr><td>184+126</td><td>1333</td><td>885</td><td>184+409</td><td>1344</td><td>895</td></tr><tr><td>186+130</td><td>1336</td><td>880</td><td>186+413</td><td>1342</td><td>891</td></tr><tr><td>188+135</td><td>1320</td><td>873</td><td>188+416</td><td>1290</td><td>905</td></tr><tr><td>190+131</td><td>1315</td><td>892</td><td>190+413</td><td>1285</td><td>895</td></tr><tr><td>192+131</td><td>1312</td><td>907</td><td>192+414</td><td>1319</td><td>883</td></tr><tr><td>194+137</td><td>1314</td><td>903</td><td>194+419</td><td>1317</td><td>890</td></tr></table>									SWCC PIPELINE -D			SWCC PIPELINE -E			Chainage (Km)	ON (-mv)	Instant off (-mv)	Chainage (Km)	ON(-mv)	Instant off(-mv)	129+642	1356	908	129+708	1360	911	131+631	1293	873	133+677	1312	885	133+616	1275	870	135+696	1295	879	135+630	1287	865	137+693	1290	877	137+627	1260	866	139+694	1283	871	139+629	1266	873	141+709	1300	879	141+643	1293	870	143+222	1327	880	143+136	1290	865	144+017	1320	886	146+126	1302	877	146+487	1351	899	148+126	1309	889	148+489	1362	912	150+132	1354	916	150+143	1345	910	152+135	1350	899	152+416	1370	918	154+118	1318	892	154+401	1358	903	156+135	1347	910	156+418	1366	917	157+993	1340	905	158+276	1362	914	160+125	1330	922	160+448	1326	919	162+147	1464	963	162+419	1380	950	164+142	1516	946	164+424	1314	908	166+156	1463	940	166+438	1404	937	168+128	1350	911	168+400	1339	915	170+128	1307	906	170+409	1311	889	172+147	1291	874	172+443	1300	885	174+134	1298	870	174+416	1307	874	176+162	1292	867	176+407	1385	877	178+125	1286	866	178+407	1280	877	180+136	1310	917	180+147	1329	903	182+133	1341	914	182+415	1337	920	184+126	1333	885	184+409	1344	895	186+130	1336	880	186+413	1342	891	188+135	1320	873	188+416	1290	905	190+131	1315	892	190+413	1285	895	192+131	1312	907	192+414	1319	883	194+137	1314	903	194+419	1317	890
	SWCC PIPELINE -D			SWCC PIPELINE -E																																																																																																																																																																																																																							
	Chainage (Km)	ON (-mv)	Instant off (-mv)	Chainage (Km)	ON(-mv)	Instant off(-mv)																																																																																																																																																																																																																					
	129+642	1356	908	129+708	1360	911																																																																																																																																																																																																																					
	131+631	1293	873	133+677	1312	885																																																																																																																																																																																																																					
	133+616	1275	870	135+696	1295	879																																																																																																																																																																																																																					
	135+630	1287	865	137+693	1290	877																																																																																																																																																																																																																					
	137+627	1260	866	139+694	1283	871																																																																																																																																																																																																																					
	139+629	1266	873	141+709	1300	879																																																																																																																																																																																																																					
	141+643	1293	870	143+222	1327	880																																																																																																																																																																																																																					
	143+136	1290	865	144+017	1320	886																																																																																																																																																																																																																					
	146+126	1302	877	146+487	1351	899																																																																																																																																																																																																																					
	148+126	1309	889	148+489	1362	912																																																																																																																																																																																																																					
	150+132	1354	916	150+143	1345	910																																																																																																																																																																																																																					
	152+135	1350	899	152+416	1370	918																																																																																																																																																																																																																					
	154+118	1318	892	154+401	1358	903																																																																																																																																																																																																																					
	156+135	1347	910	156+418	1366	917																																																																																																																																																																																																																					
	157+993	1340	905	158+276	1362	914																																																																																																																																																																																																																					
	160+125	1330	922	160+448	1326	919																																																																																																																																																																																																																					
	162+147	1464	963	162+419	1380	950																																																																																																																																																																																																																					
	164+142	1516	946	164+424	1314	908																																																																																																																																																																																																																					
	166+156	1463	940	166+438	1404	937																																																																																																																																																																																																																					
	168+128	1350	911	168+400	1339	915																																																																																																																																																																																																																					
	170+128	1307	906	170+409	1311	889																																																																																																																																																																																																																					
	172+147	1291	874	172+443	1300	885																																																																																																																																																																																																																					
	174+134	1298	870	174+416	1307	874																																																																																																																																																																																																																					
	176+162	1292	867	176+407	1385	877																																																																																																																																																																																																																					
	178+125	1286	866	178+407	1280	877																																																																																																																																																																																																																					
	180+136	1310	917	180+147	1329	903																																																																																																																																																																																																																					
	182+133	1341	914	182+415	1337	920																																																																																																																																																																																																																					
	184+126	1333	885	184+409	1344	895																																																																																																																																																																																																																					
	186+130	1336	880	186+413	1342	891																																																																																																																																																																																																																					
	188+135	1320	873	188+416	1290	905																																																																																																																																																																																																																					
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	192+131	1312	907	192+414	1319	883																																																																																																																																																																																																																					
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	<table><tr><th colspan="3">SWCC PIPELINE -D</th><th colspan="3">SWCC PIPELINE -E</th></tr><tr><th>Chainage (Km)</th><th>ON (-mv)</th><th>Instant off (-mv)</th><th>Chainage (Km)</th><th>ON(-mv)</th><th>Instant off(-mv)</th></tr><tr><td>196+115</td><td>1307</td><td>890</td><td>196+397</td><td>1312</td><td>883</td></tr><tr><td>198+110</td><td>1294</td><td>885</td><td>198+392</td><td>1287</td><td>876</td></tr><tr><td>200+121</td><td>1280</td><td>876</td><td>200+402</td><td>1285</td><td>870</td></tr><tr><td>202+114</td><td>1275</td><td>869</td><td>202+395</td><td>1277</td><td>858</td></tr><tr><td>204+114</td><td>1288</td><td>877</td><td>204+395</td><td>1291</td><td>877</td></tr><tr><td>206+107</td><td>1290</td><td>890</td><td>206+388</td><td>1308</td><td>910</td></tr><tr><td>208+130</td><td>1294</td><td>899</td><td>208+411</td><td>1305</td><td>894</td></tr><tr><td>210+121</td><td>1319</td><td>886</td><td>210+402</td><td>1322</td><td>891</td></tr><tr><td>212+112</td><td>1325</td><td>902</td><td>212+398</td><td>1318</td><td>907</td></tr><tr><td>214+106</td><td>1317</td><td>909</td><td>214+387</td><td>1320</td><td>904</td></tr><tr><td>216+105</td><td>1305</td><td>916</td><td>216+386</td><td>1310</td><td>891</td></tr><tr><td>218+116</td><td>1308</td><td>913</td><td>218+397</td><td>1303</td><td>894</td></tr><tr><td>220+123</td><td>1299</td><td>869</td><td>220+404</td><td>1309</td><td>883</td></tr><tr><td>222+105</td><td>1300</td><td>891</td><td>222+386</td><td>1315</td><td>910</td></tr><tr><td>224+118</td><td>1309</td><td>877</td><td>224+398</td><td>1312</td><td>907</td></tr><tr><td>226+119</td><td>1333</td><td>883</td><td>226+399</td><td>1340</td><td>904</td></tr><tr><td>228+126</td><td>1325</td><td>880</td><td>228+407</td><td>1278</td><td>890</td></tr><tr><td>230+102</td><td>1320</td><td>871</td><td>230+383</td><td>1270</td><td>879</td></tr><tr><td>232+310</td><td>1286</td><td>875</td><td>232+412</td><td>1267</td><td>866</td></tr><tr><td>234+413</td><td>1283</td><td>872</td><td>234+404</td><td>1290</td><td>869</td></tr><tr><td>236+121</td><td>1288</td><td>866</td><td>236+406</td><td>1303</td><td>860</td></tr><tr><td>238+125</td><td>1286</td><td>869</td><td>238+406</td><td>1301</td><td>891</td></tr><tr><td>240+130</td><td>1351</td><td>911</td><td>240+401</td><td>1336</td><td>893</td></tr><tr><td>242+124</td><td>1344</td><td>900</td><td>242+405</td><td>1338</td><td>875</td></tr><tr><td>244+124</td><td>1339</td><td>887</td><td>244+406</td><td>1345</td><td>880</td></tr><tr><td>246+119</td><td>1326</td><td>894</td><td>246+406</td><td>1292</td><td>886</td></tr><tr><td>248+107</td><td>1310</td><td>880</td><td>248+388</td><td>1280</td><td>891</td></tr><tr><td>250+122</td><td>1291</td><td>882</td><td>250+404</td><td>1300</td><td>900</td></tr><tr><td>252+135</td><td>1310</td><td>908</td><td>252+417</td><td>1316</td><td>917</td></tr><tr><td>254+118</td><td>1316</td><td>916</td><td>254+400</td><td>1318</td><td>908</td></tr><tr><td>256+124</td><td>1328</td><td>922</td><td>256+416</td><td>1330</td><td>930</td></tr><tr><td>258+105</td><td>1352</td><td>937</td><td>258+386</td><td>1359</td><td>945</td></tr><tr><td>260+138</td><td>1340</td><td>934</td><td>260+419</td><td>1354</td><td>955</td></tr></table>									SWCC PIPELINE -D			SWCC PIPELINE -E			Chainage (Km)	ON (-mv)	Instant off (-mv)	Chainage (Km)	ON(-mv)	Instant off(-mv)	196+115	1307	890	196+397	1312	883	198+110	1294	885	198+392	1287	876	200+121	1280	876	200+402	1285	870	202+114	1275	869	202+395	1277	858	204+114	1288	877	204+395	1291	877	206+107	1290	890	206+388	1308	910	208+130	1294	899	208+411	1305	894	210+121	1319	886	210+402	1322	891	212+112	1325	902	212+398	1318	907	214+106	1317	909	214+387	1320	904	216+105	1305	916	216+386	1310	891	218+116	1308	913	218+397	1303	894	220+123	1299	869	220+404	1309	883	222+105	1300	891	222+386	1315	910	224+118	1309	877	224+398	1312	907	226+119	1333	883	226+399	1340	904	228+126	1325	880	228+407	1278	890	230+102	1320	871	230+383	1270	879	232+310	1286	875	232+412	1267	866	234+413	1283	872	234+404	1290	869	236+121	1288	866	236+406	1303	860	238+125	1286	869	238+406	1301	891	240+130	1351	911	240+401	1336	893	242+124	1344	900	242+405	1338	875	244+124	1339	887	244+406	1345	880	246+119	1326	894	246+406	1292	886	248+107	1310	880	248+388	1280	891	250+122	1291	882	250+404	1300	900	252+135	1310	908	252+417	1316	917	254+118	1316	916	254+400	1318	908	256+124	1328	922	256+416	1330	930	258+105	1352	937	258+386	1359	945	260+138	1340	934	260+419	1354	955
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	232+310	1286	875	232+412	1267	866																																																																																																																																																																																																																					
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	256+124	1328	922	256+416	1330	930																																																																																																																																																																																																																					
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JUBAIL-RIYADH WATER TRANSMISSION SYSTEM		
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		Date	01-03-2020	08-07-2020	28-11-20	04-08-22		

SWCC PIPELINE -D			SWCC PIPELINE -E		
Chainage (Km)	ON (-mv)	Instant off (-mv)	Chainage (Km)	ON(-mv)	Instant off(-mv)
262+131	1364	948	262+402	1370	963
264+114	1360	943	264+314	1362	970
266+121	1358	940	266+402	1341	1011
268+135	2607	1075	268+416	2582	1066
270+088	2559	1050	270+576	2564	1042

Final Engineering	Contractor	Subcontractor
ILF	Al-Rashid Trading & Contracting Co.	SOGEC